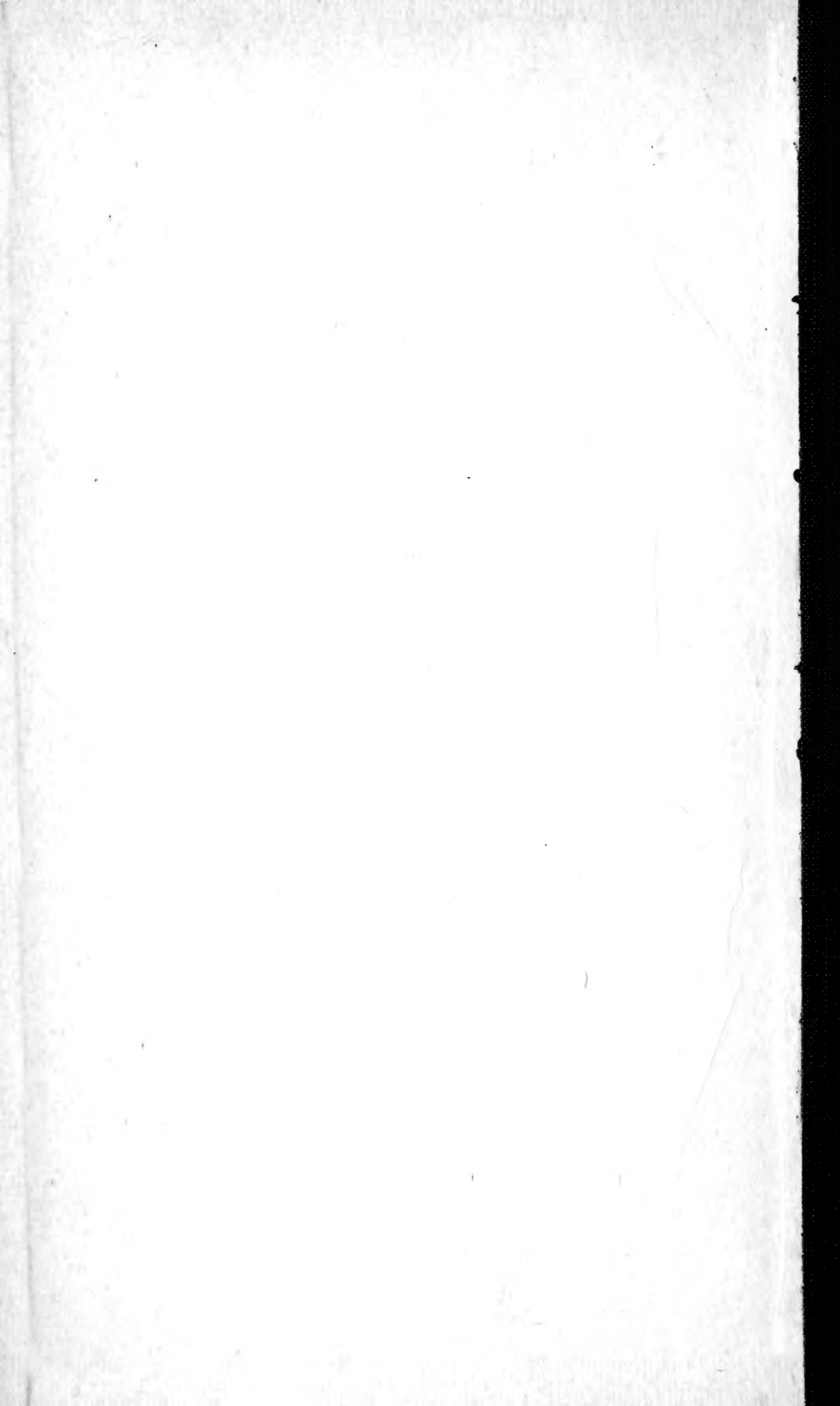


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JULY, 1917

EDUCATIONAL PREPAREDNESS FOR PEACE

By Professor JOSEPH ALEXANDER LEIGHTON

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THE word "preparedness," like other catchwords of the time, is frequently used without definition of the ends for which the country should prepare. This country is now, and somewhat belatedly, engaged in preparing to throw its full weight into the scales of battle in order to maintain and extend the principles of democratic and responsible government and to bring about a just peace in the only way now open to the world's free states, that is by beating to its knees as a suppliant German militaristic imperialism. The plans already set in train to achieve this end are fair and wise. Conscription, based on universal liability to service, is the only efficient, just and democratic means of raising a great army. Incomes should be conscripted by graduated taxation to meet the chief part of the costs of war.

But we, as a nation, should even now strive to take a longer view of things international. We should look beyond the war. The United States is in the strategic position where it can, if its citizens intelligently will, do more than any other state towards building on the results of this war the foundations of a new international order. The rudimentary beginnings of "A League of Nations to preserve Peace" already exist in the official conferences with our allies. Our cooperation involves much more than military and naval assistance. It involves international financial understandings, the international regulation of commercial shipping, of food production and distribution, of labor, of communications and news, and international scientific and technical cooperation. If we go about it in the right way, with an intelligent international mind and good will, our part in the war may be the most potent factor in bringing to an end exclusive, political and economic nationalism as a constantly disturbing factor in world-affairs. We may take the

lead in the establishment of a system of international organizations through which, in matters of banking and finance, trading, the migrations of labor, social legislation and administrative regulation of production and distribution, in fact, the internationalization of the chief material arteries and sinews of civilization, may be carried out far beyond the expectations of ante-bellum thinkers in the field of planetary politics. The internationalization of finance, commerce, the movement of labor, news-gathering, science and even art and letters was proceeding apace before the war broke out and largely without political organization. Does not the future peace and progress of humankind require the post-bellum acceleration of the process of internationalization by organization? Surely the cosmopolitan origins of our citizenry, our freedom from hereditary animosities and from the dead weight of outworn traditions, our quickness and openness of mind, our own rapid development in the socialization of democracy, and our active cooperation with all the foremost of the earth's progressive democracies, all conspire to mark out the United States as the nation which, having after long deliberation and without either racial animosity, traditional prejudice or the lust of exploitation, answered the battle call of freedom and justice, will give responsive ear and soul to the cries of the world-spirit of a humanity in travail and will take the leadership in bringing to birth the new international order built up around the Anglo-American principles of political freedom and responsibility and the French spirit of equality and comradeship. Is it not the duty of every American who can think, speak and write with a vision, however faint and vague, of a more rational future for humanity based on the principles and ideals which have nourished him, to do so without ceasing?

The supreme and ever urgent problem of world-politics is the mutual adjustment of nationalism, internationalism and democracy. And I think democracy has the key to this adjustment. The proposal to abolish nationalism is a vain and foolish dream. It can not be done and, if it could be done, the loss to mankind would be irreparable. For "humanity" without local habitation and name, without spiritual and political traditions and memories, without individuality of life, gifts, occupations and achievements, is a vicious abstraction, a barren phrase bathed in the mists of vacuous sentimentalism. The geographical, historical, cultural, and spiritual individuality of the nation is the familiar and nourishing soil on which the highest personal individuality develops and makes its specific contributions

to the life of the race. Only where the sense of social and spiritual solidarity has been strong in states and peoples have great and significant contributions been made to civilization. It was thus in the city-states of ancient Greece, especially Athens. It was thus in the Hebrew state and in republican Rome, in the renaissance city-states of Italy, in France, in England and in the German states. It is through the nurture and stimulation derived from interwoven group-individualities or spiritual wholes—the family, the school, the church, the craft, the community, the nation—that the human person grows to his full spiritual and intellectual stature, leads a full life and makes a worthy contribution to the race's material and spiritual wealth and welfare. Civilization does not grow in deserts, in dense forests, or in the eremite's cell. Not through the cult of the vague and formless abstract of "humanity" in general, but through life and action in the specific concrete and individual relations of definite social wholes, do rich and harmonious personalities, full-bodied happiness, and progressive cultures come into being and grow. The proposal to eliminate or ignore nationality, because of the evils of nationalism running riot, is on a par with the proposal to abolish the family and substitute free love and public nurseries, because of the failure of the institution of the family to attain universal perfection.

It is the nation seeking to live as an exclusive competing and dominating economic and political unit, the nation seeking territorial and commercial aggrandizement at the expense of other national units, the nation striving by foul means to get the best of the bargain, the nation puffed up with arrogance, fortified by ignorance and blindness to the worth of other nations that engenders in these days the evils of war.

The principle of democracy is the key to the situation. Democracy within the state means the equalization of opportunity for all members of the state, in order that they may be able to develop and exercise their several individualities, their native powers, in the way most effective to bring individual well-being and social welfare. The same principle must be applied to the relations of those more comprehensive individualities called "nations" and "peoples." Nations must have equal opportunities to develop and exercise their inherited and native powers (natural resources, political social and cultural traditions, the native qualities of their peoples); in short, their own specific individualities, with due regard to the like rights on the part of other peoples and to recognized standards of humane civilization and progress.

The democratization of international relations, which means their fuller moralization and humanization, will require that the nations which compose "The League to preserve a Just Peace" shall exhibit, running through their diverse cultural, geographical and economic individualities, a community of humanistic aims, interests and ideals, and that degree of similarity in political instruments and methods without which common aims and ideals can not be furthered. Only those nations in which the governmental agencies are completely responsible to the representatives, elected by vote of the whole people, for the conduct of international affairs, including the making of war and peace, will be qualified to cooperate in an International League of Peace. Only those nations in which small capitalistic groups seeking fields for exploitation, and munition makers, are powerless to influence international policies will be safe members of such a league.

An international league of peace will be nearly as powerless and ineffective in the face of a great international crisis as were the Hague Conferences, unless it has the backing of a powerful and intelligent public opinion. The development of an international and democratized public opinion, able to express itself effectively through the agencies of state in responsible governments is the only permanently effective way to reduce the chances of war. International organization, like national organization, should be the instrument of a common will; but the instrument will rust from disuse or be perverted by misuse, if there be not a common will in constant action. And a common will is nothing but a community of sentiment, thought and purpose among individual human beings and groups thereof. The sources of all volitions are blendings of instincts, emotions, ideas and images, from which arise new psychical complexes—sentiments or permanent tendencies to feel and act. The sources of public volitions are the interacting, conflicting and reinforcing sentiments of individuals. Public opinion is only the more definite articulation and forceful expression by speakers, writers, and leaders in action, of a community of dynamic sentiment in the masses. Where there is no congenital or nurtured community of sentiment there is no real public opinion, and action is then determined by the wills of small groups who hang together by community of sentiment and specific purpose playing upon the brute lusts and fears, gregariousness and pugnacity of the mass. Any oligarchy, whether it be a militaristic Junkerdom in Germany, a corrupt bureaucracy in Russia, a plutocratic group or just a gang of

political bosses in the United States, thrives and rules in essentially the same way—by sticking together and knowing just what it wants and how to get it in the absence of a community of vigorous sentiments and ideas on the part of the masses. In a final analysis political democracy means simply the conduct of the public activities of society that are necessary to the furtherance of the common weal through the resultant of the composition of forces operative in a genuine and general “public opinion.” The possibility of a lively, healthy and intelligent public opinion is just the possibility of getting the average individual to think hard and to feel keenly in regard to public questions. This is clearly a problem of education. The individual who has not been stimulated and informed in the consideration of public questions before the age of twenty-one will probably always remain an inert lump in the body politic. (One of the shrewdest bits of jesuitical pedagogy that I have ever met was the new *Vereinsgesetz* proposed in Prussia while I was in Berlin, forbidding any person to take part in political associations before the age of twenty-one.) The permanence of democracy, and the possibility of permanent peace, depend on whether the average individual can be induced to think rationally and, hence, to feel justly and act intelligently on public questions. If he can not, democracy is a vain and foolish dream.

It is from this standpoint that I am about to discuss preparedness of national spirit. I recognize that, until there is radical alteration in the international world, better industrial, commercial and military preparedness are necessary for a nation-state that is determined to maintain its own integrity. Our defenses must be as strong as the strongest until there are cogent reasons for reducing them. Probably, until the new international order has been in successful operation for some time, we should have universal compulsory training for national defense as a permanent policy. Our future national policy on this matter should be guided by the political state of the world after the terms of peace shall have been signed. “Safety first” should be our motto.

Probably, universal compulsory training would better inculcate needed habits of obedience and discipline and markedly conduce to the development of a keener sense of national and civic obligation, a more general consciousness on the part of the citizenry of their indebtedness to the institutions which protect their lives, properties and families and secure to them the opportunities to enjoy the benefits of a humane civilization; though I confess to some doubts as to whether six months or

even eleven months military training would regenerate a slacker or give public spirit to a social parasite. It would probably do something for him and it would surely develop a stronger sense of national solidarity. The schools and the universal training have been the chief agencies in the psychical unification of Germany.

I am not ready to speak confidently of the social implications and consequences of the various schemes of universal and obligatory military training, when proposed as permanent policies. If the present war does not issue in the triumph of democracy, which is, I think, in principle non-imperialistic and anti-militaristic, if the war does not result in the establishment of "A League of Peaceful Nations," too powerful to be attacked by any combination of outsiders, then the United States must put and keep its whole man-power in a permanent state of training and organization for the defense of democracy. But I fear that universal military, and even industrial, preparedness as permanent war measures may prove blind and dangerous activities, inimical to national peace and world-peace, unless our entire citizenry are more effectively instructed in right conceptions of citizenship, so that they are able to form just and intelligent views in regard to national ends and international relationships. We must be careful that physical preparedness does not engender a bellicose and arrogant attitude towards other nations. We must beware lest military preparedness become a tempting weapon of aggressive nationalism, as it has proved in Germany. The crown of all our preparedness in other lines must be an intelligent moral or spiritual preparedness. Our citizenry must be trained to exercise an enlightened national patriotism as an element in world patriotism. We need a more efficient, humanitarian and farseeing educational preparedness.

Germany offers a striking example of what can be achieved, in the way of fashioning the thoughts, sentiments and purposes of a people, by a carefully planned and conscientiously executed system of nationalistic education and training, and an equally striking warning of the dangerous results in arrogant nationalism and overweening imperialism, which follow upon a one-sided emphasis placed upon exclusively nationalistic and imperialistic aims.

The Prussianization of Germany, and the organization of its total resources, achievements and trained energies to the ends of Germanic expansion and world domination, have been accomplished through a careful and elaborate system of social

organization and an equally thorough system of educational nurture. What we, in the United States, need to emulate is, not German arrogance and imperialism, but German efficiency in organization and training to achieve the ends which are aimed at. Our national ends should and will be different, and therefore the means will not be the same. But we can learn much from the Germans. The English can learn still more. German military efficiency has a deeper basis than the system of universal military service. Both the latter and the thorough social organization which feeds and supports it have their roots in, and draw their nourishment from, the German school system. The German educational system has developed a new imperial consciousness, a new national unity of thought and feeling, of purpose and will. The German schoolmaster has been the universal and efficient instrument of national preparedness. In him and the system which he has served so faithfully have the Entente powers met their most redoubtable foe.

The new German Empire, founded in 1871, was an aggregate of separate states, without community of sentiment and tradition, without community of political organization or ideas, without unity of thought and purpose. Between some of its chief constituent states there was much inherited mistrust, even ill will. The Bavarian and the Württemberger disliked the Prussian, while the Prussian had contempt for them. Sectional social, religious and political differences of long standing made the Empire seem but a loose aggregate, held together by a combination of pressure from without and Prussian energy and masterfulness within. In a trifle longer time than a generation there has been welded together, out of these heterogeneous and even hostile traditions and interests, one great people organized and directed by trained intelligence to achieve stupendous social, industrial and political ends.

Of the industrial and commercial progress made in this short period by Germany it is now superfluous to speak. Every intelligent person knows about it. Of the organization of the industrial, economic and social life for the furtherance of the common weal—of old-age pensions and accident insurance, of state-operated railroad, telegraph and telephone services, of well-planned and well-managed municipalities, of municipal gardens, theaters, music and art galleries—it is unnecessary to speak at length.

On the present direction of this highly organized, vigorous and intelligent national life towards an aggressive and ruthless policy of national expansion one need not comment. It is the

other side of the picture. A magnificent system of cultural and social organization has been prostituted to these ends, because the control of the whole system has been in the hands of a bureaucracy dominated by militaristic and imperialistic ideas and led by an arch-imperialistic autocrat.

It is a much easier task to direct a people bred to political docility, habituated in submission to direction from above, than it is to direct a democracy. Moreover, the rulers in bureaucratically governed countries have the great advantage of being able to get together and agree on the aims which they shall pursue, unhampered by the democratic babel. Both educational and social organization can be carried out more smoothly and efficiently in a nation of the German type than in a democracy. Thus the splendid development of German cultural organization has become the ready tool for a deliberate attempt at world-mastery. Though we may reprobate some of the ends sought and the means employed, Germany's example is none the less thought-compelling.

A new world-situation will ensue upon the cessation of this war, and, if Western civilization is not to expire, strangled in the Nessus shirt of its conflicting nationalistic imperialisms, a new world-organization must be built up. In that new world an American may believe and should resolve that democracy will occupy the place of leadership. If we Americans respond to the duty laid upon us by the insistent hour, world leadership should, in large measure, fall to the United States. We owe it to the world's future, as well as to our own future, to prepare to execute our stewardship.

The impending future of the world calls in clamant and urgent tones for a new international political system. The time is now near at hand for the liberally-minded nations to organize for the maintenance of permanent peace, by the formation of some sort of international agreement, and the establishment of some sort of tribunal with power to settle international disputes and to make war both difficult and dangerous to enter upon. The organization must be based upon the democratic principles of equality and justice among nations. It can come into being and continue in being only if democratic principles prevail more and more effectively in national governments all over the earth. These principles will prevail only if the leading democratic states develop greater clearness of conception, firmness of conviction, and effective cooperation with respect to the rules of conduct for states as members of the international order. The very foundations of an international

order are yet to be laid. Dynasts, militarists, capitalists and diplomats can not be trusted to lay these foundations. They must be laid in the moral and social intelligence and feeling of the earth's peoples. The extension of democracy and the cultivation of its political intelligence are the only sure roads to lasting peace. The development of sympathy depends upon the development of understanding. To understand is to sympathize. Therefore international sympathy and forbearance, international justice and equity, are predicated upon international understanding; and only through the growth of intelligent democracy is increase of international understanding possible. The will of man is not a separate psychological entity that operates on its own hook. A man's will consists of his interests, organized and directed by intelligence. So with a nation's will. International good will will follow upon an intelligent recognition of community and interdependence of interests among the *peoples*. This community and this interdependence of interests does not exist among dynastic autocrats, oligarchic governing castes, militarists, money-lenders, and the diplomatic tools of these interlocking directorates of nations. But community and interdependence of interests does exist among all the peoples of this earth, if they can only be brought to see it by the training of their political and social intelligences. When they do see it they will cease to be led by the nose to slaughter at the behests of their rulers.

The fundamental and essential condition for the maintenance and spread of peace, based on a fair and humane international order, is the effective operation of an intelligent and therefore a just humane and peaceful public opinion within the several nations—a public opinion which shall exercise control over the nation's policies in both national and international concerns. The time has arrived when the voter, who may have to do the fighting, must learn to think clearly and act vigorously in terms of the nation's moral relations to other nations, in terms of the nation's duties and responsibilities, no less than of its rights and privileges, in the comity of nations.

The United States is a great world-state. It must prepare to function more intelligently and vigorously as a leader among states. It must assume its part in the pains and efforts of the world to bring to birth and fruition a new moral world-order. The American must acquire the habit of thinking in international terms. He must learn to consider his domestic social and political problems, the organization of industry and commerce, the production and distribution of wealth, protection

and free trade, the development of science and education, in the light of world organization; in the light of the same problems as they exist for other states. The days of our isolation have been long past, but many of us did not awaken to cognizance of the fact until the world-war rudely disturbed our parochial habits of mind and action and we found, to our irritation and perplexity, that we are our brother's keepers and that we can not stand apart from the dominating world-currents and remain a great state. In the past three years of our national life there have been many happenings on our own soil as well as on the high seas that will cause our heirs to look back with feelings other than unmingled satisfaction upon the recent past. It can not be said that we have acquitted ourselves with unqualified distinction as protagonists of international justice and humanity, defenders of the rights of non-combatants and neutrals and defenders of our own national rights. And the causes are only in part the presence on our soil of so many children and grandchildren of the warring nations who have striven to import into the determination of our policies, in delicate and complicated international situations, the national sympathies and antipathies of their European origins. The causes are also in part the unintelligent isolation and ignorant disregard of international affairs in which our people have been nurtured and have lived. We have been so engrossed with the material and cultural development of our native resources, with building up an industrial democracy on a virgin continent, that we have neglected international questions. We have some good excuses. Owing to our geographical isolation and our economic self-sufficiency, we have not been frequently threatened by international conflicts. We set out upon our national career with a happy unity of language and institutions, and we fortunately discovered the great principle of federation and successfully maintained it in the civil war. The great variety of languages, traditions and institutions, which lend such picturesque charm to Europe in days of peace, are the unhappy sources of conflict which force the intelligent European to be more internationally minded.

Our geographical isolation has been annihilated by rapid transit and well-nigh instantaneous communication. The exploits of German submarines off our coast have demonstrated that we can not any longer hide behind the seas in time of war. For the purposes of both peace and war the world is fast becoming unified. Our social task at home is now, not so much the exploitation of nature as it is the elimination of the ex-

ploitations of man by man, the social control of economic production and distribution for the development of a more equitable and richer type of commonweal. Thus in the economic problems and conditions of our domestic life, we are rapidly approaching the status of Europe before the war. After the war the same problems of social organization for equalization of opportunity will confront America and Europe; with this difference, that our economic power will be greater than Europe's, and therefore it will be harder for us to practise saving and efficient cooperation. We shall not suffer so acutely from the war as Europe is suffering. Europe will become both more democratically socialized and more efficiently organized. The methods of national organization, necessitated by the war, will not be scrapped. Before the war Germany was the most highly socialized country in Europe; but the authority and initiative in this process resided in an oligocratic bureaucracy. The results of the war will, in all probability, discredit and weaken the Prussianized oligarchy, as it is already doing in Russia. Germany and Russia will, I think, inevitably become much more democratic. England, France and Italy, which were rapidly developing in the direction of socialized democracy before the war, will probably continue to do so at an accelerated pace. Our economic and industrial life must undergo a corresponding socialization if our nation is to continue in the lead. This socialization must not be a mere war-measure. It must be permanent. Since social and political intelligence, impelled by moral sentiment "in widest commonalty spread," is the only hope for an efficient, honest and progressive democracy, the task of education is of paramount importance. In a democracy of our type the keys to the progressive or evolutionary solution of national and international social problems must be forged in the homes, the schools and the colleges.

The supreme task of the school in a democracy is education for the intelligent practise of citizenship in the nation and in the world. Such problems as vocational training, or the respective values of science and language study are secondary in importance. The schools must prepare the embryo citizens to be good citizens, not simply to make a living. If they be given sound elementary instruction in their mother tongue, in elementary mathematics and science with especial reference to its applications, and if their bodies and characters are developed in a physically and morally sound environment in the home, school and community, there will be no trouble in regard to their making a living. (The ensuring of the sound environment of

course involves considerable social readjustment.) The schools must prepare the coming citizens to be good citizens of the nation and the world. And I do not see how this can be done without systematic instruction in the elements of social and political ethics. As matters stand now many a good workman or business man is a poor citizen, when it comes to the exercise of his public duties.

The American public has of late been told repeatedly, and by some persons who should know better, that Germany's success in the war has been due to her assiduous cultivation of science and her neglect of the humanities, and that England's slowness and early failure were due to her neglect of science; whereas England's ability to get widespread sympathy for her case in neutral countries has been due to her emphasis on the humanities in education. The explanation is too simple and is not in accord with the facts. England had been a citizen of the world these many centuries, whereas Germany is a new-comer. The British Empire is a world-encircling cluster of democracies. England has had long practise in international dealings. The English are men of the world to a much greater extent than the Germans. Moreover, democracies, especially if they be of the same speech, will instinctively sympathize with a democracy, North Americans with the English (and for historic reasons with the French), South Americans with the Latins.

Germany's success has been due, aside from her long and arduous military and naval preparations for war, to her power of intelligent organization and her highly developed national consciousness. This organization is the result chiefly of two factors—a splendid and long-established system of universal public education and a greater socialization of the instruments of social well-being. England's failures (and, of course, to a vastly greater extent, Russia's failures) have been due to the comparative neglect, until recently, to establish a universal system of free public education, and to the economic individualism which has failed to furnish decent means of sustenance for much of her population.

The lessons of this conflict, up to date, are not that science has superior fighting value to the humanities in education. Germany has maintained the study of the humanities, without neglecting to develop education in science. In all probability (I have not the figures) a larger proportion of German boys than of English boys study Latin, modern languages, and history. The lesson of the conflict is the tremendous national

power and efficiency that is engendered by a universal system of public education, organized and conducted as part of a coherent scheme of social organization; in contrast with a more or less hap-hazard and go-as-you-please national activity in education and industry. The issue is between the national organization and control of education to national ends, by the development of the best technique made accessible to all, and the leaving of educational control and enterprise at the mercy of local politics, sectarian religious prejudices, parochial parsimony and unintelligence. Germany is reading the world an effective lesson in the value of the control of education by the state and the enforcement of high standards of educational efficiency, as the condition of national efficiency. At the same time the example of Germany warns us that national education should be directed towards international welfare in place of a chauvinistic national expansion. The nation will fail in the future and will lay up trouble for itself and the world, if it does not make training in social and international ethics, the education of its citizens to be intelligent members of the world's democracy of states, an integral part of its universal and public scheme of education. The coming citizens should be trained as if a world federation were coming into being through their efforts. Only in this way will an effective international organization for peace with justice ever really come into being. I venture to make some suggestions as to how this end may be set about.

What is most urgently needed in public school education is not so much a concordat between the conflicting claims of the natural sciences and the humanities, as it is science, literature and history all taught in a more liberal, more inspirational and humanistic spirit, as expressions and instruments in humanity's universal struggle towards liberation and self-fulfilment. The primary aim of public education in the schools should be, not the development of technical skill in the handling of physical processes (that will come later for those who need it) nor the development of dialectical subtlety through grammar nor the stimulation of the ability to solve puzzles through tricky mathematics; it should be humanistic inspiration and ethical and social enlightenment through the study of literature and history, and of science treated as a humanistic instrument of social progress, followed by the study of social and international ethics, which are the keys to politics and civics. Literature and history, including the story of the growth of the scientific spirit, taught as records of the progressive moralization of the

human soul, as instruments of ethical and intellectual inspiration and enlightenment, as the progressive expression and record of the human spirit in its struggles towards more intelligent and harmonious individual self-development and social integration, should be the basis of all our education. Thus the average citizen should develop a more vivid and intelligent sense of the moral foundations of international relationships, as well as of intranational social relationships, and a stronger and more enlightened conviction in regard to the moral and rational forces operative in history. For history can best be taught as the working out, on large-scale patterns in space and time, of a moral and rational world-order, of the progressing refinement and increasing recognition of ethical values, and of the steady elevation of the human race through the more effective realization of just and humane purposes, through the operation of social intelligence. So to teach history that the working of a moral and rational order is discerned therein is not to distort the facts. It is rather to select, organize and interpret the facts that are worthy of perpetuation and study. It is the only method of dealing with historical study that justifies the labor and time spent upon it, by finding in it meaning and worth for living humanity. Otherwise history becomes the disconnected, muddled and dispiriting tale of an endless, purposeless sequence of events, conducing only to mental ennui and moral pessimism in its students.

Literature, science and history should be taught in a more humanitarian, cultural and cosmopolitan spirit. We have, in our own tongue, a literature including the English Bible that is unrivalled perhaps, certainly not surpassed, by any other in its wealth of concrete instructional and inspirational material for the nurture of the moral spirit, a great thesaurus of moral and spiritual example compacted of the creative imagination. What is lacking in teaching literature is the selection and arrangement of this rich material in an order corresponding to the stages in the psychological development of childhood and youth. There is also a dearth of teachers qualified, by experience, training and personal power, to open up the treasures of literature and history, and to draw out their ethical applications to the individual life, and, more especially, to the moral issues of the social and international orders.

In the final analysis every social problem and every political issue, whether in the municipality, the state, the nation, or international affairs, is an ethical problem—a problem in human conduct, to be solved by the exercise of an intelligent good will.

Every conflict in these social fields is between a lesser good and a greater good, between a best and a good which, by opposing the best, becomes the bad in that particular connection; between individual interest and the welfare of a group, between class interest and a wider common weal, or between a chauvinistic nationalism and a just and humane internationalism. It is quite as important that the ordinary citizen should be equipped with the tools and the materials for intelligent reflection and action in regard to matters of international conduct and misconduct as that he should be equipped to think intelligently and fairly in regard to the principles and facts of conduct between fellow-citizens or business associates or neighbors or members of his own family. "Social justice" can not be realized apart from international justice, nor international justice apart from social justice within the nation. As the world becomes more and more unified, economically, industrially and by interchange of methods of organization and thinking, it will become more and more impossible to settle large issues of national policy without regard to the international issues involved therein. Behind every issue now in regard to international rights and obligations, political sovereignty, trade arrangements, national autonomy and national expansion, there is a moral issue which is usually obscured by a tangle of legal and diplomatic verbiage or hidden by the devious ways of international finance or by the fuming vapors of a narrow and exclusive nationalism. The German invasion of Belgium, for example, involved a plain moral issue which the German government and its professorial henchmen have sought to cover up, but have egregiously failed to do.

If law and administration within the nation must be controlled by moral principles, it is equally true that trade arrangements and all diplomatic and treaty relations between nations must be similarly controlled, as indeed the laws on international copyright, extradition, protection of the persons of nationals, navigation and postal matters are now controlled. There can not be one standard of equitable dealing between citizens of the same state and an entirely different standard, or no standard at all, between states. The present war exemplifies, upon a more stupendous scale than any previous international conflict, the enormous folly and cost of educating the citizens of a state in their duties towards one another, as members one of another, and at the same time denying or ignoring the existence of any parallel international obligations or common membership and participation in the life of humanity. The war is a tragically

stupid catastrophe, precipitated primarily because German intelligence ceased to operate beyond the German boundary.

We could dispense in our schools with a good deal of the abstruse mathematics and grammatical technique now taught. But, at our peril and at peril to humankind, we dispense with the moral stimulation and enlightenment of literature and with the instruction and warnings of social and political history, when these are effectively taught. We can no longer afford to neglect the teaching of social ethics and civics in the setting of world-civics and world-politics. If national and international politics are not to be devil's games, they must become fields for the application of the common man's instructed moral insight. A democratic state can not safely leave instruction in civic ethics to the homes and the churches.

Furthermore, if we are to get an efficient training of our coming citizenry in the ethics of civic and social relationships viewed as a part of the totality of humane world-relationships, we must have a national control of education to national and international ends. Our state-systems of education are not sufficiently centralized. There is too little control over the standards of teaching and the contents of the curricula. The appointment of teachers is too much subject to local politics and local parsimony. The states should control standards and curricula more effectively. They should have a check upon salaries and appointments. But, in this matter, the cure might be worse than the disease if state superintendencies and boards are not entirely removed from the vicissitudes of state politics.

The nation, through its department of education, should control the standards of teaching and the minimal contents of the curricula. We have heard much lately in regard to the "New Nationalism" and the "New Americanism," but little as to what these catchwords mean. I would have the new nationalism and the new Americanism include, as paramount features, intellectual and moral preparedness for the maintenance of a peace founded upon international justice, through effective national control of the educational instruments for training in the principles of citizenship and world citizenship.

We shall never secure a high educational efficiency in this country until the states compel a higher economic and scholastic minimum for the teacher—until by state action the economic, professional and social status of the teacher is considerably improved, and thus abler and more vigorous personalities are induced to make teaching their vocation. And we can not be sure that this purpose will be speedily consummated, unless the

national government has the power to enforce it on the several states. Local autonomy unregulated too often becomes chaos and sometimes remains chaos.

We shall never ensure that the coming citizenry is decently instructed in the elementary moral principles of citizenship and receives adequate enlightenment upon the ethics of social, national and international relationships, until the national department of education has power and authority to prescribe a minimal program of instruction in civics and social and international ethics, based upon a more broadly and humanistically conceived program in history and literature—in short *the nation* must effectively require that in every nook and corner of this broad land the boy and the girl are brought to exercise their intelligences upon, and apply their consciences to, the fundamental issues of social and political ethics in their national and international bearings, no less than upon matters of private personal relationships. Can anything be more important in a nation in which public opinion makes policies, or should make them, and in which if public opinion does not shape policies they are shaped by ringsters and grafters or by cliques and third-rate pothouse politicians? In an autocracy the people are relieved of moral responsibilities for public policies by the imperial keeper of their consciences. “Theirs not to ask the reason why, Theirs but to do or die.” In a democracy there is no keeper of the public conscience. If the people do not jointly and severally keep their own political consciences there is none. And conscience is not kept by lack of training and exercise. It dies if it is not used. Is there any subject of more paramount and urgent concern to a democracy than instruction, training and reflection in public ethics. If it is worth while for the state to educate future mechanics and tradesmen, farmers and professionals, surely it is ten times more worth while to educate future citizens to be *citizens*. Nay more, it is suicidal for the public agencies to take care of all the specialized educational interests and neglect the basic general interest in a nation that, by hypothesis, is made up, not of mechanical puppets pulled by autocratic strings, but of intelligent freemen able to conduct their own affairs.

RACE SUICIDE IN THE UNITED STATES

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THERE are many people who think that race suicide means there is little or no natural increase (annual excess of births over deaths) in our population. Well-informed students of our population questions, however, have never used the term in this sense. They have never feared that our population was not growing rapidly enough by natural increase to hold its own with that of other countries. Professor Ross originally used the term—race suicide—to characterize what he believed to be a movement in the growth of our population leading to the extinction of the older native stock and its replacement with the newer immigrant stocks—the Slavic, the Latin and the Hebrew. According to this view our vital population questions are not questions of mere numbers but rather questions of quality.

Are the people of the older stock—those of Anglo-Saxon and Teutonic descent—gradually dying out and are they being replaced by the immigrants from southern and eastern Europe? If this is the case what are the effects upon our civilization going to be? These are the questions of vital concern to Americans. Those who believe that the older stock is dying out are quite likely to believe that with it are going the ideals and aspirations which have made America distinctive among the nations of the world. They feel that these new peoples with different racial traits, with different national histories and with different cultures are certain to make an America, not only different from but inferior to, what it would be if left in the possession of the older stock.

THE EVIDENCE OF RACE SUICIDE

Most of the evidence of race suicide comes from investigations made in New England. In Boston it was found that the old American stock has a natural increase of only about one per thousand per annum. As the report points out this is probably too low a rate of increase to represent the condition of the old native stock in other parts of the state but yet it shows that this stock is increasing very slowly. The rate of natural increase for the whole state is about ten per thousand per annum.

There is no room for doubt, therefore, that the newer stock is rapidly becoming a larger proportion of the entire population.

Another investigation giving much the same results was made by the Immigration Commission. It was found that in Rhode Island the native white women of native parentage who had been married from ten to twenty years had borne an average of 2.5 children, while the white women of foreign parentage had borne an average of 4.5 children. Thus the women of newer immigrant stock bore almost twice as many children as the women of native stock.

Experience and observation also confirm the more exact investigations. Those familiar with conditions in New England have borne almost universal testimony to the effect that the families of the older native people are smaller than those of the newer immigrant peoples.

There seems to be but one conclusion that has been drawn from such facts, viz., that the newer immigrants and their descendants are steadily becoming a larger proportion of the whole population. Without waiting to see whether other investigations in other parts of the nation would give similar results most people who have discussed this question have assumed that there is a general movement of this nature in our population. The result is that there has been a great hue and cry raised against race suicide. Before we join in this outcry, however, and indiscriminately urge people to raise larger families as some have already done, we should examine the facts more carefully.

There is very good reason to believe that the movement of population in New England is not typical of all parts of the United States. In the first place, New England has a larger urban and industrial population than any other section of the country. If, therefore, there is any difference in the rates of natural increase in the urban and rural populations they would not show in their true proportions in a study of the movement of population in New England. Besides most of the investigations and observations already referred to have been made in the cities. In the second place, the very fact that New England has a very large proportion of immigrants may have a direct effect upon the rate of natural increase of the native population. General Walker pointed out long ago that immigration was, in part, at least, a substitution of incoming peoples for those who would have been born to native parents had the immigrants not come. In the third place, the number of children born to native and foreign mothers is not a good measure of

THE PROPORTION OF CHILDREN TO WOMEN IN THE URBAN AND RURAL
COMMUNITIES OF THE UNITED STATES, ALSO IN CERTAIN SELECTED
CITIES AND FOREIGN COUNTRIES

Geographic Area	No. Children Under 5 Yrs. per 1,000 Women 15-44 Yrs.	No. Children 5-9 Yrs. per 1,000 Women 15-44 Yrs.	Per Cent. of Total Popula- tion Comprised by Women 15-44	Per Cent. of Total Popula- tion Native Born of Native Parents
United States :				
Urban, white	382	341	25.4	41.9
Rural, white.....	603	555	21.2	64.1
Urban, negro *.....	290	298	31.0	6.3
Rural, negro *.....	652	641	22.5	14.5
New England States :				
Urban, white	384	345	25.7	33.9
Rural, white.....	458	437	20.4	69.8
Middle Atlantic States :				
Urban, white	402	351	26.2	34.4
Rural, white.....	518	477	21.2	67.0
East North Central States :				
Urban, white	382	340	25.9	41.7
Rural, white.....	523	506	21.3	66.5
West North Central States :				
Urban, white	344	317	26.4	51.2
Rural, white.....	582	548	21.3	58.5
South Atlantic States :				
Urban, white	393	354	26.4	54.2
Rural, white.....	678	604	21.5	62.2
Urban, negro	296	298	31.1	29.4
Rural, negro.....	689	666	22.1	35.2
East South Central States :				
Urban, white	378	349	26.7	54.4
Rural, white.....	696	619	21.6	67.2
Urban, negro	272	281	31.1	32.3
Rural, negro.....	620	609	22.9	31.4
West South Central States :				
Urban, white	405	384	26.0	58.4
Rural, white.....	729	658	21.2	67.7
Urban, negro	298	317	30.6	22.3
Rural, negro.....	621	636	22.7	22.7
Mountain States :				
Urban, white	382	350	25.5	51.9
Rural, white.....	641	564	19.9	57.8
Pacific States :				
Urban, white	301	271	25.7	46.9
Rural, white.....	509	480	19.9	54.8
Boston, white.....	354	316	27.1	23.5
Fall River, white.....	445	397	26.4	13.3
New York City, white.....	394	341	27.2	19.3
Pittsburgh, white.....	420	354	26.0	33.0
Chicago, white.....	390	333	26.5	20.4
Cincinnati, white.....	294	266	27.7	42.6
Cleveland, white.....	433	349	25.9	23.6
Indianapolis, white.....	292	282	27.7	64.5
Milwaukee, white	388	345	26.1	21.1
Kansas City, Mo., white	270	248	28.6	61.9
Minneapolis, white.....	312	267	27.6	31.9
St. Louis, white	325	294	27.5	39.3
Baltimore, white.....	360	343	26.6	46.8

* This includes only the negro population of the South Atlantic, the East South Central and the West South Central States.

Geographic Area	No. Children Under 5 Yrs. per 1,000 Women 15-44 Yrs.	No. Children 5-9 Yrs. per 1,000 Women 15-44 Yrs.	Per Cent. of Total Popula- tion Comprised by Women 15-44	Per Cent. of Total Popula- tion Native Born of Native Parents
Birmingham, white.....	459	398	26.0	50.0
New Orleans, white.....	371	367	26.4	43.5
Salt Lake City, white.....	442	372	25.7	41.1
San Francisco, white.....	278	238	25.6	27.7
Seattle, white.....	286	256	25.6	44.6
United States, 1910 (white only)...	484	440	23.3	
Australia, 1911.....	499	431	23.6	
German Empire, 1910	535	499	22.8	
France, 1901.....	409	367	22.8	
England and Wales, 1901.....	458	429	25.0	
1911.....	429	411	25.0	
Sweden, 1910	522	490	21.5	
Italy, 1911.....	566	492	22.0	
Russia (European), 1897.....	675	543	22.4	

the respective rates of natural increase. The death rate of the children of immigrants is much higher than that of children of natives. The presumption, then, is decidedly against accepting the view that the movement of population in New England is typical of all parts of the United States.

THE MOVEMENT OF THE POPULATION IN THE DIFFERENT SECTIONS OF THE UNITED STATES

In order to show the relative rates of increase of the urban and rural populations in different parts of the country I have prepared the table on p. 24. In this table the number of children 0-4 and 5-9 years of age (columns 1 and 2) per 1,000 women of child-bearing age—15-44 years of age—is given for a number of the different geographical and political units of the nation. The proportion of women 15-44 years of age and the proportion of native population to the whole population (columns 3 and 4) are also given for each of these units. At the end of the table will be found some of the same data for a few foreign countries.

Although this is not the most accurate way possible of measuring the rate of natural increase in different classes of the population and in different sections of the country, it is the best at present available and, on the whole, gives us a very good notion of the movements now taking place. The proportion of children to married, widowed and divorced women would not be as good an index of natural increase, because the presence of a large number of unmarried women or women who marry late in life, as in our city population at present, is in itself a proof of race suicide. To eliminate these women from the cal-

culations would, therefore, be to secure a measure of the relative size of the family in the country and the city rather than a measure of the natural increase.

The following data will show, however, that the conclusions to be drawn from the table referred to above would be corroborated by a more detailed study showing the proportion of children to married women.

NUMBER OF CHILDREN UNDER 5 YEARS OF AGE PER 1,000 MARRIED, WIDOWED, OR DIVORCED WOMEN 15-44 YEARS OF AGE IN THE URBAN AND RURAL COMMUNITIES OF THE UNITED STATES AND ITS GEOGRAPHIC DIVISIONS (WHITE POPULATION ONLY)

	Urban	Rural
United States	660	933
New England	714	718
Middle Atlantic	709	827
East North Central	645	828
West North Central	599	937
South Atlantic	672	1066
East South Central	632	1047
West South Central	633	1050
Mountain	601	907
Pacific	489	754

The fact standing out most clearly in the table given above is that in every state the proportion of children to women is greater in the country than in the cities. In the New England States as a whole the number of children under five years of age to 1,000 women is 19.3 per cent. greater in the rural districts than in the urban. In all the other geographical divisions of the nation the difference is even greater than in New England. In the Middle Atlantic States it is 28.8 per cent., in the East North Central States it is 36.9 per cent., while in the West South Central States it is 80.0 per cent. These facts show beyond question that the rural population has a greater rate of natural increase than the city population.

The full significance of this fact only becomes apparent, however, when we compare the proportion of native population in these two classes of communities. The proportion of native stock is invariably greater in the country than in the city. The greatest differences are to be found in New England and the Middle Atlantic States, but the difference is also considerable in the East North Central States. In the other parts of the nation the differences are not very large. It is also worth noting that in those sections where the differences are greatest the foreign stock in the cities is of the newer immigration,

while in those sections where the differences are comparatively small the foreigners in both country and city are of the older immigration.

THE INCREASE OF NATIVE AND FOREIGN STOCK IN THE CITIES.

The proportion of children to women in the urban population shows a remarkable uniformity throughout the United States. Only in the West North Central and Pacific States does the proportion fall below 375 per 1,000 and it exceeds 425 in only a few of the states—chiefly the southern states. But in spite of this great uniformity, it is apparent that those urban communities of the north and west of which the newer immigrants form a large proportion have a greater number of children per 1,000 women than those in which the proportion of native stock, or older immigrant stock, is large.

This appears more clearly if instead of confining our attention to the geographical divisions we pick out certain cities representative of different elements of the population. Practically any of the larger cities in the northeastern part of the country have a large proportion of the newer immigrants. Boston, New York, Chicago, Cleveland and Detroit, as well as many others, have a proportion of children much greater than Indianapolis, Kansas City, Denver and Los Angeles. In the former, people of the newer immigrant stocks predominate, while in the latter native stock predominates. In such cities as Cincinnati, St. Louis, Milwaukee and Minneapolis, where the older immigrant stocks (chiefly German and Scandinavian) predominate and there is also a good proportion of native stock the proportion of children is smaller than in the cities with the newer immigrant stocks, but larger than in the cities where native stock predominates. In the distinctly southern cities, however, where the white population is almost entirely native stock, the proportion of children is little, if any, smaller than in the northern cities with a large proportion of the newer immigrant stock. But only a small proportion of the city population of the United States is to be found in the southern states.

If, then, it were a question of the relative rates of natural increase of the native and immigrant stocks in our urban population only, there can be no doubt that the newer immigrants would become a steadily increasing proportion of the whole, with the older immigrants a poor second and the native stock an "also ran." But the urban population was only about 46 per cent. of our entire population at the last census. Therefore, before we become unduly excited about the extinction of the

Anglo-Saxon and Teutonic stock in our country, let us examine the data showing the proportion of children to women in the rural districts rather carefully.

THE INCREASE OF THE RURAL POPULATION COMPARED WITH THAT OF THE URBAN POPULATION

Although, as was pointed out above, the proportion of children in the rural districts is everywhere greater than in the cities, there is by no means as great a uniformity in this proportion in the country as in the city. There are three general divisions into which the states fall with respect to the proportion of children to women in the rural population:

1. *The New England and the Atlantic Coast States as Far South as Delaware.*—In these states the number of children varies from 412 in Massachusetts to 493 in Maine. This is the smallest proportion for any group of states. In all these states the rural population is a relatively small proportion of the whole and is largely composed of the old native stock. There has been a selective process going on for several generations in the rural population of these states. The more active, wide-awake, and ambitious men and women have either gone west to new lands or they have migrated to the cities to seek their fortunes. This has had a detrimental effect upon country life and is probably responsible in large measure both for the decadent population now to be found in the rural districts of these states and the unprogressive character of the farming carried on there.

2. *The States of the Northern, Central and Western Part of the Country.*—In these states there is a wide variation in the proportion of children to women. In general, however, they have more than 500 and less than 600. California and Nevada have less than 500, while the Dakotas and some of the other northwestern states have over 600. There does not seem to be any close relation between the foreign stock and a large proportion of children to women in these states. It is true that North Dakota with a very large foreign element in the rural population has over 700 children per 1,000 women, but there are several states with a preponderantly native element in the population which have a larger number of children per 1,000 women than Minnesota and Wisconsin, in which the population is largely composed of Germans and Scandinavians and their children. In those states where frontier conditions still exist, we almost invariably find a relatively large proportion of children. Thus the proportion of children in the rural population

seems to depend on the opportunities open to children in the country rather than on whether the people are old native stock or the older immigrant stock. The relatively small proportion of children in some of the far western states which still have frontier conditions is probably due largely to the greater independence and self-assertion of the western woman.

3. *The Southern and Southwestern States.*—In these states the number of children rarely falls below 650 per 1,000 women and in many exceeds 700 (we are discussing the white population only). In all these states the rural population is almost entirely composed of the old native stock. In the West South Central States about 10 per cent. of the population is of foreign stock. In the South Atlantic States only about 2.5 per cent. of it is of foreign stock, while in the East South Central States the proportion is even smaller. We are, therefore, justified in speaking of the rural population of this third great division as a native population, and it is in this part of our population that the greatest natural increase is taking place. As in the western states, where pioneer conditions still exist, the opportunities for children to do as well as their parents are relatively good here, and this is one of the important reasons for the high proportion of children.

Of our entire white population 51.3 per cent. lives in the rural districts, the remainder in the cities. In 36.6 per cent. of the rural population there are 650 or more children per 1,000 women; in 52.5 per cent. of it there are 500 to 650 children per 1,000 women, while in only 10.9 per cent. does the number of children fall below 500 per 1,000 women. In only 25.0 per cent. of the urban population, on the other hand, does the number of children rise above 400 per 1,000 women. Of this 25.0 per cent. over one fourth lives in the southern states, where the white population of the cities is almost entirely native stock. The other three fourths live in Connecticut, Pennsylvania and New Jersey, in none of which the number of children exceeds 433 per 1,000 women. Of our total white population in which the number of children exceeds 400 per 1,000 women, six sevenths live in the rural districts and one seventh in the urban.

The number of Italians, Slavs and Jews—the newer immigrants—to be found in the rural districts of the great agricultural states is negligible. On the other hand, the number of Germans, Scandinavians, English and Irish and their children is large, approximately one fourth of the entire rural white population being of these stocks.

In view of these facts, I can see no reason to be alarmed over

the rate of natural increase of the newer immigrants. They are not increasing as rapidly as the native and older immigrant peoples by excess of births over deaths. Although the relative rates of natural increase of the urban and rural population can not be calculated with exactness from the data given here, I have estimated them at 5 and 15, respectively. That is to say, in ten years the urban population would increase approximately 5 per cent., and the rural population 15 per cent. by natural increase. I believe that these estimates are conservative both with respect to the absolute rates in the two classes and with respect to the difference between these rates.

The reason for this difference between the rates of natural increase in the urban and rural population will be discussed in what follows.

REASONS FOR THE RATES OF NATURAL INCREASE OF THE DIFFERENT CLASSES IN OUR POPULATION

The reasons for the difference between the rates of natural increase in the urban and rural populations fall in two general classes: (1) Those which explain the difference in the death rates of these classes, and (2) those which explain the difference in the birth rates.

REASONS FOR THE DIFFERENCE IN DEATH RATES

The following table gives in very brief form the best data available regarding the difference between the death rates of our urban and rural populations:

NUMBER OF DEATHS PER ANNUM PER 1,000 PERSONS LIVING AT DIFFERENT
AGES FOR MALES AND FEMALES IN THE ORIGINAL REGISTRATION
STATES: 1910 (WHITES ONLY)

	Males		Females	
	Urban	Rural	Urban	Rural
Under 1 year of age.....	133.80	103.26	111.23	84.97
During tenth year of age.....	2.88	2.17	2.52	1.88
“ twentieth year of age.....	4.49	4.31	3.82	3.97
“ thirtieth year of age.....	6.83	5.33	6.08	5.44
“ fortieth year of age.....	11.61	6.90	8.58	6.53
“ fiftieth year of age.....	18.34	10.24	13.74	9.43
“ sixtieth year of age.....	36.07	21.19	28.65	18.72
“ seventieth year of age.....	69.42	48.79	59.16	45.12

This table shows that the death rates for both sexes are much lower in the country than in the city, with the exception that the death rate for women at about twenty years of age is

slightly higher in the country. It is worth noting too that the greatest excess of deaths in the cities occurs at the ages when the death rates are high. This would have the effect of raising the general death rate in the city much above that of the country. The general death rate in the country is probably about 13 per 1,000 per annum, while the general death rate in the cities is not less than 16 or 17 per 1,000. Thus if the country and city had the same birth rates, the country population would increase 3 or 4 per cent. more in ten years than the city population.

The outdoor life of country people is one of the important factors in keeping the rural death rate down. Country children spend most of their waking time, outside of school hours, out in the open. In going to and coming from school, at their chores and during their vacations country children get an abundance of good fresh air. They do not know what it is to breathe the dust- and germ-laden air which the city child must always breathe. The men spend even more of their time out in the open than the children. All their work takes them out into the sunshine and fresh air. They never feel the confinement of factories and stores, nor the blight of occupational diseases. They can not understand that work in reasonable quantity may be injurious to health, because they do not know the conditions under which many industrial workers ply their trades. The women, of course, do not live in the open as the children and men. But they get much out-of-door life during the warmer part of the year. They have their gardens to care for, the chickens to raise and many other light chores which take them out-of-doors. Besides if the country woman goes anywhere she does not go in a crowded street car. She is out in the open air in a buggy or automobile. There can be no doubt that the way of the country woman is more healthful.

There is room for much criticism of the country home because of its poor ventilation, lack of adequate heating and methods of sewage disposal. In spite of these deficiencies, however, there are very few country homes as unhealthful as the great number of tenement homes in the cities. The crowding of people together in small poorly ventilated and poorly lighted apartments, which is common among the lower classes of people in the larger cities, has no counterpart in the country. In hot weather when the city tenement dwellers suffer most from crowding and unsanitary living conditions, country people can get out-of-doors where there is always an abundance of fresh air and plenty of room for recreation. From whatever standpoint we contrast urban and rural conditions—from that of

conditions of work, from that of conditions of recreation and play, or from that of home conditions—we find that the out-of-doors, open-air life of country people gives them a decided advantage over city people in the matter of health.

Another reason for the lower death rate in the rural districts is that the country people are closer to the source of food and therefore have purer food than city people. In view of our present system of distribution it may seem to many that this is a relatively unimportant cause of better health in the country. It does not seem so to me, however. Country people have their own fresh vegetables in season and instead of buying canned vegetables for winter use put them up for themselves. They still raise much of their own meat—especially pork and poultry and veal. They also have eggs and milk and butter of the best and in abundance. Well-to-do people in the city can secure fresh and pure food, but the great majority of people have difficulty in doing so, as it is beyond their means. The very poor often use food which is entirely unfit for human consumption. The high death rate in this class is in part a result of this unhealthy diet.

In those classes in the city whose food is good there is a very large number of persons leading sedentary lives. These men are quite apt to overeat and underexercise, so that they do not use up their food and get rid of waste matter. The active life of the farmer, on the other hand, renders it unlikely that he will suffer from hearty eating. I have often been impressed by the fact that one sees many more soft flabby men among those pursuing sedentary occupations in the cities than among the farmers.

The relative security of the farmer's position is another reason for the low death rate in the country. He is not harassed by the uncertainty of his job and his income, as a great proportion of the salaried and wage-earning classes in the city. He does not need to fear that some machine will be invented to take his job, nor that he will be turned off in hard times because of lack of work. There is no danger that his industry will move away from him, forcing him to take up some new work or spend all of his savings to move his family to a new home. Nor do strikes and lock-outs affect the farmer in any appreciable degree. Besides, he does not have to compete with an ever renewed supply of immigrant laborers. The farmer has his "hard luck" as the city laborers, but it is not likely to force him into such dire straits as the former. If crops are a failure the whole neighborhood feels it, but no farmer is likely to lose

his position as a farmer because of that. He receives a temporary set-back and must curtail expenses, but he is in no danger of being in need of charity. This absence of worry on the part of the farmer no doubt helps to keep him healthy.

There is also very good reason to believe that the burden of accidents, industrial and other, falls more heavily on the city population than on the country population. Certain it is that a casual perusal of the daily papers leaves this impression. But more significant is the fact that it is the practise of insurance companies selling insurance to the lower classes in the cities, to charge them a much higher premium than they do farmers and those in other occupations. There seems to me to be no doubt that a part of the greater risk assumed in the case of hand laborers is due to the greater frequency of accident in this class.

Moreover, accidents in the city have more indirect effects contributing to a high death rate than they have in the country. Even with compensation from the employer, the city man's family is more likely to become destitute than the farmer's if he is injured. The farmer has more resources to fall back upon. For one thing the farmer's family is still an economic unit, in which each member, from a very early age, contributes something to the welfare of the whole, while in the city the workingman's family is very largely dependent upon him alone until the children are old enough to escape the provisions of the child labor laws. Besides even when the city boy can go to work, he can not at once take the place of his father, except in the unskilled occupations in which it is practically impossible for a man, single-handed, to make a living for himself and family. The farmer boy, on the other hand, can do his father's work in a pinch, and thus hold the fort until his father gets better. Even the wife and daughters can help in case of necessity and they often do. Then, too, neighborliness is more common in the country and can render greater assistance without savoring of charity than in the city. I would not imply that country people are naturally more kindly than city people, only that they live in such intimate daily relations that personal friendly aid of great value can be rendered in which there is no thought of condescension in the givers and no feeling of self-abasement in the recipients. Friendly aid of his neighbors has saved many a farmer from the worry of wondering how he was to care for his family during the coming winter. The city worker in the same situation would almost certainly have to look to charity to help him through. The different conditions of life make it

almost inevitable that accidents should entail more hardship and suffering on the workingman's family in the city than on the farmer's in the country.

Still another cause of the lower death rate in the country is what may be called the lower tension of competition in the rural districts. At whatever point one undertakes a comparison of urban and rural life with respect to the nature of their competitive processes, one finds a lower tension in the country.

For one thing, there is not the intense competition for place among men in the country that there is in the city. In the industrial and commercial world positions are graded so that there is always a more desirable one just ahead. This keeps the ambitious man continually striving for a better place and, since there are always more men who want the places just ahead than are needed to fill them, there is a constant struggle to secure them. There is no place one can stop to take a breath without fear that some one will step in ahead of him.

Among laboring men there is a somewhat similar process going on. Perhaps not quite so strenuous as among those in executive positions and the professions, but nevertheless quite strenuous enough to take a great deal of one's energies. There is the never-ending conflict of the skilled artisan with the machine designed to do his work; there is the constant change in methods and processes to which the man who has become settled in his habits finds it difficult to adjust himself; there is the competition between the immigrant and the unskilled worker, and to-day there is also the competition between men and women in numerous lines of work. All this striving for better places and to keep one's place is almost unknown in the country. The farmer may become old-fashioned and yet make a good living. He has very little need to fear that some one else can crowd him out if he does not want to go. And yet in many farming communities there is enough emulation to keep the farmer truly progressive.

Another way in which the difference between the country and the city in respect to competition manifests itself is in the attitude of the women toward dress. The continuous incitement to dress well and to vie with one's neighbors to which the city woman is subject is very largely lacking in the country. The city woman is forever seeing the new styles in the stores or on the streets, and she very soon comes to feel that she might just as well be out of the world as out-of-date. Besides in the city the success of the husband and the social position of the family are judged very largely by the outward show the family

makes. So "good-dressing" by the women is more than the satisfaction of personal vanity, it is the assertion of the right to a certain social position in the community. It is quite natural that this should be so in our modern cities, where people only know their neighbors by the clothes they wear and the automobiles they drive.

The country woman, on the other hand, does not need to assert her claims to a social position for the family by the way she and her daughters dress. Her neighbors know whether her husband owns his farm and whether he loans or borrows money. She can not impress her neighbors with outward show. In addition, the security of her position and in many cases the substantial prosperity of the family probably renders her more or less indifferent to the outward show of things. When people have back of them a secure and definite position in the community, they can afford to be less careful about the passing impressions they make. For this reason a majority of the farmers' wives care little about any luster they may add to the position of the family through the kind of competition for social position ordinarily practised by city people.

So it seems to me that from whatever angle we compare competition in the city and country, we find that the country requires less of its dwellers than the city and is therefore more favorable to good health.

(To be continued)

COAL MINING IN CHINA

By Dr. ALFRED C. REED

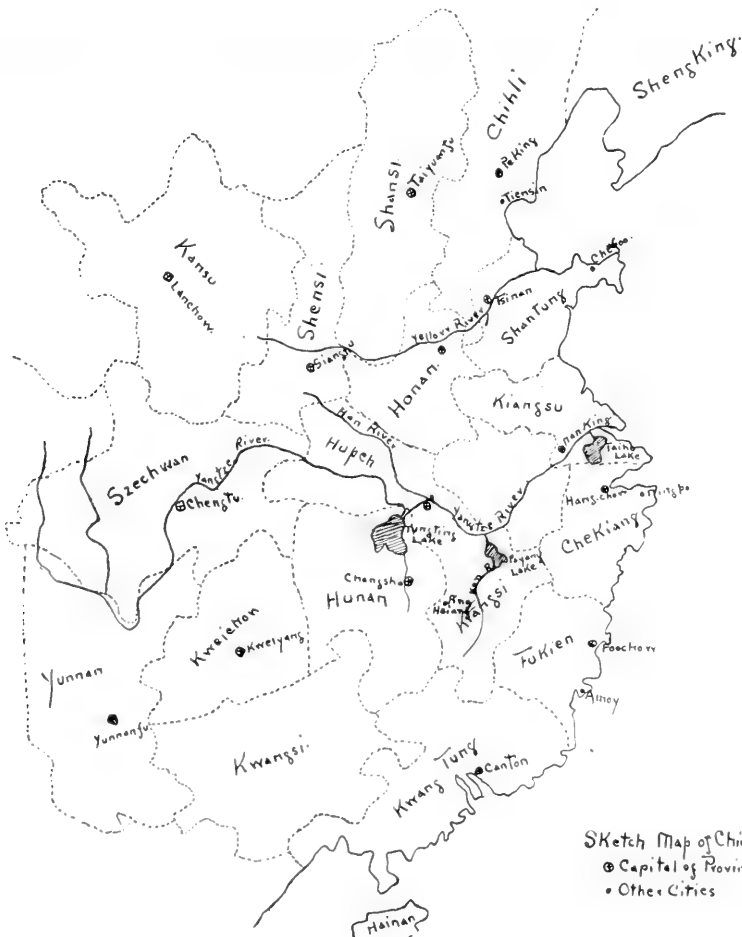
SAN FRANCISCO

THE great central valley of China, extending from Thibet in the far west to the Yellow Sea, is drained by the Yang Tze River and its tributaries. South of that part of the Yang Tze which flows through the mid-part of the eighteen provinces is a vast section centering in the province of Kiangsi and extending southward to the ranges cutting off the watershed of the South China coast, in which are some of the most extensive coal fields in the world. This southern watershed crosses the extreme south of Kiangsi and Hunan. Practically all of Kiangsi and the southern section of Hunan have large coal deposits as well as abundant iron and limestone, and more or less extensive quantities of antimony, manganese, lead, copper and silver.

The largest coal mine in China, the Ping Hsiang Colliery, was started in 1894 on the site of native diggings which had been worked for unknown ages near Ping Hsiang in Kiangsi. Five miles from this walled city is the village of An Yuen, the terminus of a railroad running to Changsha, the capital of Hunan. At this village, 90 miles from Changsha, is the Ping Hsiang Colliery, which produces 2,400 tons of coal and 700 tons of coke daily, and employs 9,000 men. An Yuen lies on the watershed between the Siangtung River running west into the Siang River in Hunan which empties through the Tung Ting Lake into the Yang Tze, and the Siu River running east into the Kan River in Kiangsi, which empties through the Poyang Lake into the Yang Tze. Southeast of the village is the high range of the Lo Siao Mountains in which are the coal fields. This range varies in altitude from one to two thousand feet, and the main level of the colliery in the valley is about 500 feet above the sea-level at Shanghai. The Ping Hsiang colliery is in east longitude 114 degrees and in north latitude 27 degrees and 30 minutes. The one way of approach is through Hunan where large river steamers from Hankow reach Changsha. The railroad from Changsha to An Yuen is part of the Canton-Hankow system which originally was an American concession, but later was transferred to the British. Only this section, with short spurs

at either end from Hankow and Canton, has so far been completed after many years of wordy strife and paper planning. A new British concession has, however, been granted to connect Changsha with Ningpo by way of Ping Hsiang, with a branch midway to Hankow. This would open up vast deposits of coal and iron now practically inaccessible.

The Ping Hsiang Colliery supplies the coke for the Hanyang Iron Works, which are across the mouth of the Han River from Hankow. The coal output is distributed to the territory from Changsha and Siangtan to Hankow and even further down the Yang Tze. Both coke and coal are transported by rail from An Yuen to Chuchow on the Siang River, where they are loaded on junks and lighters for further transportation. The technical operation of the Ping Hsiang colliery is under the direction of a



staff of twelve German engineers who are applying the most up-to-date methods of mining and coal preparation. In its twenty years under foreign supervision the colliery has grown to extensive proportions. Improvements now under construction will within six months increase the output to 3,500 tons per day. Entrance to the mine is twofold, first, by way of the main adit going straight into the mountain for a distance of 2,500 meters horizontally from the floor of the valley, and second, by a pair of shafts 300 and 500 feet deep, respectively. The shaft division is the older and smaller and its output is about 700 tons per day. It includes only the deeper levels where the seams dip below the level of the main adit. The bulk of the mine, reached through the main adit, is above the level of the valley floor and comprises a total of five levels, each with numerous lateral drifts following in each seam. The highest level is near the summit of the chief mountain of the range, and egress to the outer air could easily be obtained at many points.

The main adit runs straight into the mountain for a distance of 2,000 meters before reaching the main or lowest level, where a wide haulage way runs at right angles to it. The adit has two parallel tracks for an electric tramway running its full length, which in the outer 200 meters are increased to eight tracks. Here the first electric railway in China was put into operation fifteen years ago, and has been maintained ever since. The trains attain a speed of twenty-five miles per hour.



SKETCH MAP OF THE PROVINCES OF HUNAN AND KIANGSI.



ADMINISTRATION BUILDING, PING HSIANG COLLIERY.

The coal seams run in three groups. The first group encountered by the main adit has the thickest seams and these are inclined at an angle of twenty degrees to the adit. At the junction of the adit and first group of coal veins is the main level of the mine running transversely to the adit, with lateral drifts following the seam up and down according to its inclination. Five hundred meters past the point where it pierces the first group of coal veins, the main adit pierces a second and smaller group inclined also at an angle of twenty degrees and parallel to the first group. Still deeper in the mountain is a third group which has been worked out.

The seams are thus all transverse to the main adit and inclined upward and away from it at a 20-degree angle. Lateral inclined drifts from the main level follow up each seam for from 120 to 160 meters to the first level, which runs horizontally in the plane of the seams, and in turn has lateral inclined drifts following the seams. The first level is connected with the main level not only by the inclined drifts following the seams, but also by vertical shafts. Higher yet in the line of the seams are the second, third and fourth levels, the last being well toward the summit of the range. The accompanying sketches show the inclination of the seams and the general schematic relations of the main adit and shaft to the various levels.

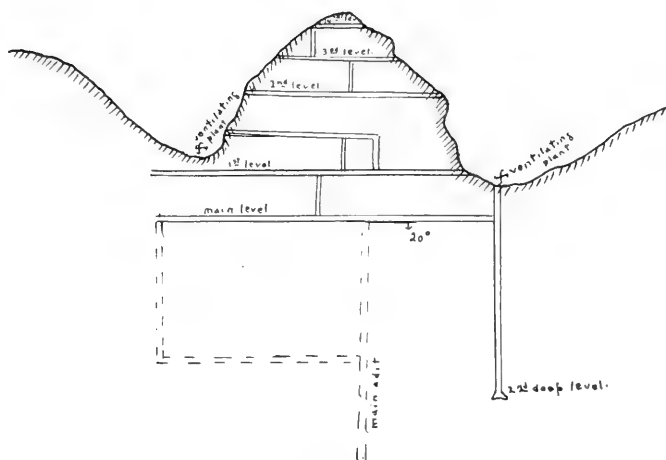
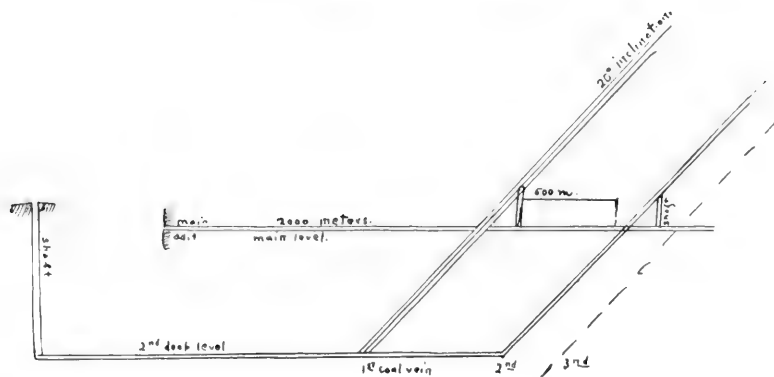
Below the level of the main adit there are two deep levels, communicating with the main level, but with haulage ways tributary to the double shaft. The arrangement of these deep levels

and the manner of communication between them, by means of lateral inclined drifts in the seams, are similar to the arrangement in the upper levels. The general lay-out of the mine as well as its operation is simplified by the fact that the two groups of coal veins, a little below the main level, are turned at an angle of 90 degrees still however maintaining their original inclination. This enables the combination of approach by a shaft and by a horizontal main adit to be most effective and also facilitates the ventilation. At present the ventilation is maintained by a combination of compressed air piped throughout the mine, together with two large air-heating furnaces which establish a strong upward draft. A new system of electric blowers is now being installed. The ventilation is remarkably good for so extensive a field of operation.

Among the drawbacks are the prevalence of mine fires, which are controlled by sealing off the entire section with several meters of wet clay, and faults in the strata which occur at various points and necessitate abrupt changes in drifts and elevations. A picture is shown herewith which illustrates a fault where the strata have not been broken, but have been bent through an angle of 90 degrees. The equipment for fighting mine-gas and fires is the same as in western countries and oxygen helmets are always at hand in the two rescue stations for emergencies.

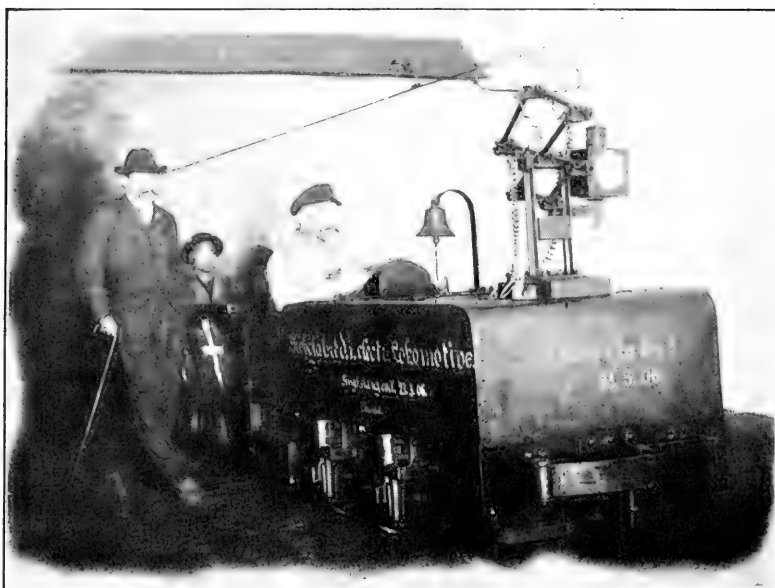


THE LACHOW SEAM OF THE PING HSIANG COLLIERY. The drawing is not sufficiently clear to give a good reproduction, but the general arrangement of the levels is shown.



ELEVATIONS OF MINE.

Throughout the mine heavy timbering is necessary, and this constitutes one of the chief items of operating expense. In the seams and in very soft strata, a layer of pine twigs and straw is placed between the wall and roof and the heavy timbering to prevent coal dust and sand from working between the timbers and producing excavations of constantly growing proportions. With these fagots of twigs and straw countless insects are brought in. Scorpions six inches in length are fairly common but stings are infrequent. Cockroaches swarm by the millions and furnish part of the regular diet of the hosts of rats which find in the warm dark mine a safe abiding-place. Ants also are a great annoyance to the miners.



ELECTRIC LOCOMOTIVE, MANUFACTURED AND USED IN PING HSIANG COLLIERY.

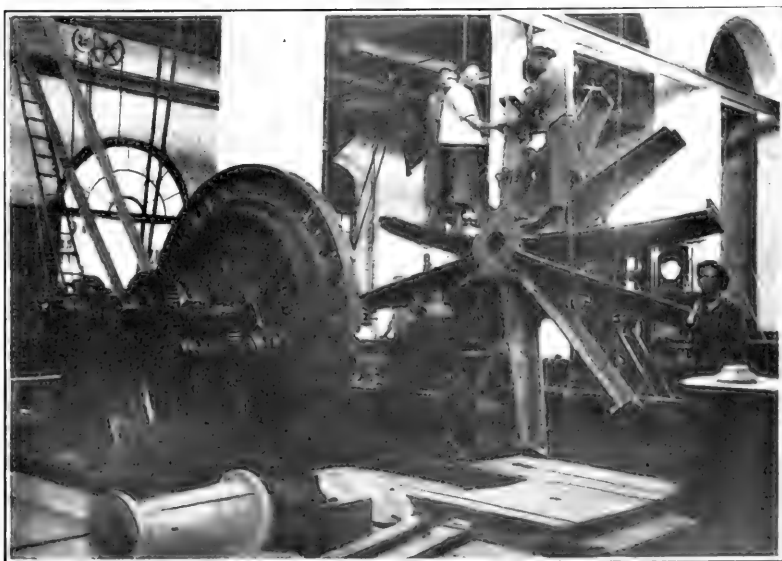
The above-ground works of the Ping Hsiang Colliery are extensive and modern. The freshly mined coal is taken on the tram-ways directly to the two washing plants, one for the shaft and one for the main adit. Here it is elevated to the top of the building, thoroughly mixed with water, cleaned, separated from slate, schist, clay and sand, and graded into various sizes. As only bituminous coal occurs, a large percentage is in the form of dust, and this is washed as thin slime into large sedimentation tanks thirty-five feet in depth. From the bottom of these tanks it is scraped by chain elevators, and deposited in storage tanks from which it is carried as a wet solid mass to the coke ovens. No anthracite is found and the soft coal is of such quality as to produce coke of the best quality, of excellent hardness and which fractures in large pieces, considerations of importance in the steel manufactory.

The foreign coke ovens number 262, each of which produces five tons of coke every forty-eight hours, giving a total output of about 700 tons of coke per day. Part of the gas from the coke ovens is used for developing electric power, but so far no other utilization of by-products has been introduced. There is a shameful waste here, as one ton of coal produces during the carbonizing process about 10,000 cubic feet of gas, fifteen to twenty-five pounds of ammonium sulphate, and from four to eight gallons of tar. But capital is hard to secure in central China and

the cost of the machinery installation necessary to secure these by-products is estimated at a million dollars gold.

Large and well-equipped machine shops turn out most of the machinery used in the colliery, including engines, pumps and tools. Many of the shop lathes and drilling machines were made here. All the car wheels and other castings necessary in so large a plant are cast in the local foundry. Electric power is developed for all purposes in the colliery. Another industry within an industry is found at the large brick yards on the mountain side not far from the colliery. Here the clay is pressed by hand and kiln-dried. The bricks are carried to all parts of the mine by coolies.

A total of nearly 9,000 men are employed, of whom about 6,000 work underground. Two shifts are run of twelve hours each. Work is suspended, not on Sundays, but on the first and fifteenth of each month. The coolies who work underground are divided into gangs of from ten to a hundred men each, according to the situation of their work. Each gang has its headman. About ten gangs, depending on their size, make up a section. Each tram-car of coal which leaves the mine is marked with the number of the gang which mined it and is credited to that gang. In drifts through rock and earth, the gang is paid according to meter of length and according to whether the drift is of single, or double, track caliber. A single track drift has a cross section of about 2.5 square meters. The absolute size of



MACHINE SHOPS. LARGEST SINGLE CASTING MADE AT PING HSIANG COLLIERY.



END OF A DRIFT.

the drift is determined by the amount of air which must pass through it for efficient ventilation.

No coolie will do more than one kind of work. One set does timbering alone. Another cuts coal. Another does the carrying in baskets, and pushing the tram-cars in drifts not fitted with electric or cable propulsion. Next come the miners who do the coal and rock cutting, then the coolies who scrape the coal and *débris* into baskets and carry it out. It is a strange fact that the shovel is unknown in China. Everywhere and for every purpose for which a western laborer would use a shovel the coolie uses an implement half between a mattock and a hoe, with which he scrapes the earth or whatever it may be into shallow baskets. The wage of the mine coolies averages twenty cents Mex., about nine cents gold, per day; the miners about thirty cents, thirteen cents gold; for the twelve-hour shift. The coolies live in company boarding houses where they are a little better under control. The cost per man for board and lodging is about eight cents Mex. per day, to which must be added four and one half cents per day for oil for lights in the mine. The total expense to the company is thus between forty-five and fifty cents Mex. per day for each coolie. Each section in the mine has four overseers, including one apprentice. Every effort is made by the foreign staff to develop native mining engineers and to this end apprentices are employed throughout the works, who later receive both theoretical and practical instruction in mining engineering and foreign languages.

The output of coal per miner is somewhat under one half ton per day in distinction to the European average of one ton per day and more, and this is in spite or perhaps partly because of the long hours and infrequent holidays. Indeed many factors contribute to this result, among which may be mentioned very prominently the presence of hookworm infection in high degree. The mine coolies are much better housed and fed by the company than if left to their own resources, but their physical capacity is quite limited. The methods of drilling and blasting are similar to those in western countries.

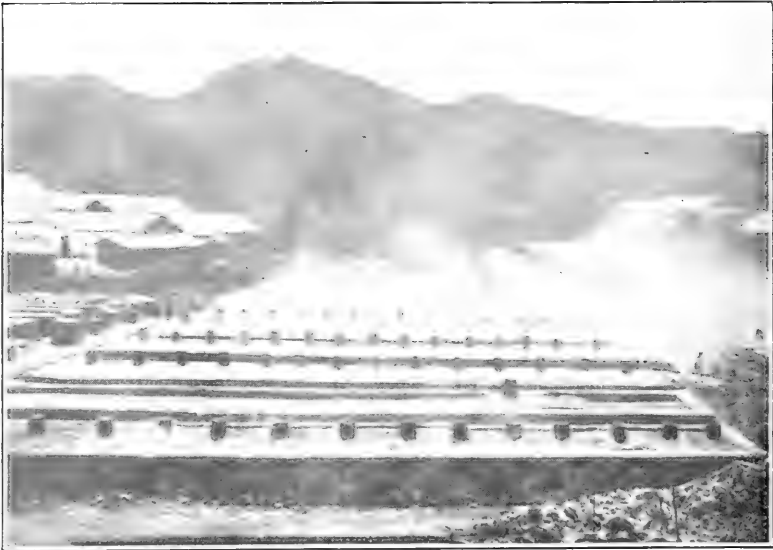
The coolie class is intractable, unreliable, and has no outlook either as to their own or their country's future. They reflect in a petty way the same qualities which now and always have been too much in evidence among their countrymen in higher circles. "Face," "squeeze" and dishonesty are the crying vices of the Chinese people, and it is these particular qualities which make foreign development of China most difficult and which make absolutely imperative an actual and effective supervision of foreign loans to China.

Just south of the washing plants and coke-burning kilns of the Ping Hsiang Colliery is an area of perhaps five acres enclosed by a high brick wall and given over to coke production according to native methods. The "beehive," or native ovens, differ radically from the foreign and no machinery is used in filling or emptying them. The human beast of burden does



A FAULT, IN WHICH THE STRATA ARE BENT BUT NOT BROKEN. Photograph in Ping Hsiang Colliery.

everything by simple force of numbers and persistence. The native kiln is constructed in a unique but effective manner. A long trench is formed about 12 feet wide and from 20 to 50 yards in length, by two brick walls some 30 inches in height. These retaining walls are about the thickness of two brick lengths, and at intervals of perhaps 8 feet are fitted with apertures a foot wide by 18 inches high through which the firing is started.



NATIVE "BEEHIVE" COKE OVENS BURNING. Coal-bearing range in background.

These broad and comparatively shallow trenches are provided with a smooth floor of packed clay and are then filled solid with wet coal dust except for a small space left opposite each aperture in the retaining walls. Every bit of the coal is carried by coolies in small baskets balanced on poles across the shoulders. The coal is of first quality, coming from the washing plants of the Ping Hsiang colliery. The trenches are filled to a depth of two and a half feet and then rows of brick are laid on edge over the entire surface, and on these a second layer of brick are laid flat covering the entire space. Along the center of the trench at points midway between the firing apertures in the retaining walls, small flues are made with brick, and then the entire surface is covered with sand. By means of a little lump coal and wood, fires are now started in each of the firing apertures, and soon the entire interior of the trench, forming a single long low kiln, is in process of combustion. A good draught is

quickly established between the firing apertures and the flues, and the gases are quite thoroughly consumed. From the entire area a thin cloud of smoke and vapor rises, but there is remarkably little unoxidized material. The heat evolved is a total waste except for its value for the coolies' cooking.

Even more interesting than the "beehive" coke ovens are the native coal mines, of which there are large numbers in southern Hunan and southwestern Kiangsi. In the coal fields near Ping Hsiang there are numerous native mines on both sides of the range. These native mines are a sore grievance to the Ping Hsiang colliery because of drainage conditions. The native mines are always located where the coal seams pinch out at the surface, and are always comparatively shallow, seldom extending more than a few hundred feet into the mountain. Their slanting shafts quite thoroughly collect most of the surface waters which are held above the clay strata overlying the deeper drifts of the large colliery. The upper levels of the colliery naturally approach nearest the surface at the localities where the coal seams outcrop. The result is that the surface waters collected in large quantity by the native mines are drained off to a great degree by the upper levels and drifts of the colliery and these highest parts of the colliery are consequently the wettest by far. The native mines are frequently however in a state of practical flood. The description here given is based on an extensive investigation covering upwards of 200 native mines, undertaken by Mr. M. Esterer, of the Ping Hsiang Colliery.

In digging shafts and laterals, the native miner avoids rock so far as possible, though he has copied foreign methods of drilling and blasting. The diggings are largely in the seams and consequently have many tortuous and narrow passages. The shaft of the native mine follows the vein from the surface, usually at an inclination of from 20 to 60 degrees. After a varying distance the shaft or drift becomes horizontal and then rises, still following the vein. The result is the formation of an elbow towards which the water flows from both directions. This necessitates constant pumping to keep the passage open, and even then the water stands from one to two feet deep for a variable distance. Through this water every person must walk on entering and leaving the mine. Pumping is effected by manpower, as machinery is never used. A long section of a large bamboo, 6 to 8 inches in diameter, is cleaned out, making a circular smooth pipe. Into one end of this a crude valve is fitted and into the opposite end is introduced a piston with valve. This pump is laid along the slanting floor of the shaft and



MR. CHANG. Chinese Founder of Ping Hsiang Colliery.

operated by a coolie who sits at its upper extremity. The water is caught in a small pool lined with clay from which it is pumped by a second similar apparatus at a higher level. A sufficient number of these relay bamboo pumps are provided to reach the surface.

As the shafts are never vertical and all work is done by man-labor, some special means is necessary for transporting the coal to the surface. Bamboo or plain wooden ladders with the rungs characteristically close together, so that each step is not over 6 to 10 inches, are laid against the sloping floor and secured by pegs or bamboo withes. The upright side pieces of these ladders are very close together, leaving not more than 6 to 8 inches

for the feet to tread. Coal, earth and rock are scraped into small baskets which are pulled by ropes by a coolie who mounts on the rungs of the ladder, with the basket sliding on the side-bars after him. The coal is deposited in a heap at the pit mouth and carried thence in baskets by coolies again to Ping Hsiang or some point on the river where it can be placed in junks.

The native mines are insufferably hot, due to the entire absence of any ventilation system, to the small caliber and single bore of the shafts, and to the large number of persons at work in the mines at once. The average is 30 to 35 degrees Centigrade. This temperature, with the darkness and abundant moisture, favors the growth of parasites such as the hookworm, which here finds ideal conditions for propagation. Some of these mines have a daily output of 30 to 40 tons, but most are much smaller. The coal districts are thickly dotted with native mines, but all are most superficial, and where the seams dip away from the surface they have not been touched. No natural gas or oil has so far been found in the south Yang Tze coal fields, but no deep borings have as yet been made.

THE HEALTHIEST OF MEN

By Dr. JAMES FREDERICK ROGERS

NEW HAVEN, CONN.

“**W**ERE one to preach a sermon on Health, as really were worth doing,” said Thomas Carlyle, “Scott ought to be the text,” for Sir Walter was “an eminently well-conditioned man, healthy in body, healthy in soul; we will call him one of the healthiest of men. . . . On the whole, we might say,” that “in the new vesture of the nineteenth century” he “was intrinsically very much the old fighting Borderer of prior centuries. . . . In the saddle, with the foray-spear, he would have acquitted himself as he did at the desk with his pen. . . . He could have fought at Redswire, cracking crowns with the fiercest, if that had been the task; could have harried cattle in Tyndale, repaying injury with compound interest.” The author of “Ivanhoe” preached in his life a greater sermon on health than even Carlyle could have composed, and, fortunately, we have, straight from his own genial pen, many facts about his physical experiences and unfolding, with additional interesting details from that of his son-in-law, Lockhart.

Like some other giants of literature—Johnson, Gibbon and Dickens—this healthiest of men did not make a very heroic start in life. Scott says:

I showed every sign of health and strength until I was about eighteen months old. One night, I have been told, I showed great reluctance to be caught and put to bed, and after being chased about the room, was apprehended and consigned to my dormitory with some difficulty. It was the last time I was to show such personal agility. In the morning I was discovered to be affected with the fever which often accompanies the cutting of large teeth. It held on three days. On the fourth when they went to bathe me as usual, they discovered that I had lost the power of my right leg. . . . There appeared to be no dislocation or sprain; blisters and other topical remedies were applied in vain.

The disease was (according to Dr. Charles Creighton) an inflammation of the bones of the leg just above the ankle, which, from its painfulness, prohibited its use at the time, and interfered with its complete growth later. Scott continues:

My anxious parent during the course of many years, eagerly grasped at every prospect of cure which was held out by the promise of empirics,

or of ancient ladies or gentlemen who conceived themselves entitled to recommend various remedies, some of which were of a nature sufficiently singular. But the advice of my grandfather, Dr. Rutherford, that I should be sent to reside in the country, to give the chance of natural exertion, excited by free air and liberty, was first resorted to; and before I have the recollection of the slightest event, I was, agreeably to this friendly counsel, an inmate in the farmhouse of Sandy-Knowe. . . . Among the odd remedies recurred to aid my lameness, some one had recommended that so often as a sheep was killed for the use of the family, I should be stripped, and swathed up in the skin, warm as it was flayed from the carcass of the animal. . . .

I was in my fourth year when my father was advised that the Bath waters might be of some advantage to my lameness. . . . My health was by this time a good deal confirmed by the country air, and the influence of that imperceptible and unfatiguing exercise to which the good sense of my grandfather had subjected me; for when the day was fine I was usually carried out and laid down beside the old shepherd, among the crags or rocks round which he fed his sheep. The impatience of a child soon inclined me to struggle with my infirmity, and I began, by degrees, to stand, to walk, and to run. Although the limb affected was much shrunk and contracted, my general health . . . was much strengthened by being frequently in the open air, and, in a word, I, who, in a city, had probably been condemned to hopeless and helpless decrepitude, was now a healthy, high-spirited, and, my lameness apart, a sturdy child.

An illness or accident is sometimes a blessing in disguise, and possibly had Sir Walter not been so crippled in his early years he might not have been led into his love of books nor have drunk in the tales of romance from the lips of the country folk with whom his lameness had thrown him. He learned also the lure of the historic country where he lived which later sent him on many a pedestrian tour in which he unconsciously collected the material for his future works. As Carlyle puts it,

Disease, which is superficial, and issues in outward "lameness" does not cloud the young existence; rather, forwards it towards the expression it was fitted for.

His mind became strong on the varied food it gathered from every source, but his body did not yet give promise of much vigor. His attendance at school was consequently irregular, but though he was poor in some studies he was "neither a dunce nor an idler." Along the lines of his own bent he was "one who wished to know and will know everything." He says:

At the age of sixteen my health, which, from rapid growth and other causes, had been hitherto rather uncertain and delicate, was affected by the breaking of a blood vessel. The regimen I had to undergo on this occasion was far from agreeable. It was spring, and the weather raw and cold, yet I was confined to bed with a single blanket, and bled and blistered till I scarcely had a pulse left. I had all the appetite of a growing boy, but was prohibited any sustenance beyond what was absolutely neces-

sary for the support of nature, and that in vegetables alone. Above all, with a considerable disposition to talk, I was not permitted to open my lips without one or two old ladies who watched my couch being ready at once to souse me,

“imposing silence, with a stilly sound.”

Lockhart says the bleeding was from a vessel of the bowel and that “his uncle, Dr. Rutherford, considered his recovery from it as little less than miraculous. His sweet temper and calm courage were no doubt important elements of safety.” Waverly continues:

My constitution recovered from the injury it had sustained, though for several months afterwards I was restricted to a severe vegetable diet . . . and though I gained health under this necessary restriction, yet it was far from being agreeable to me, and I was affected whilst under its influence with a nervousness which I never felt before or since. A disposition to start upon slight alarms—a want of decision in feeling and acting, which has not usually been my failing—and acute sensibility to trifling inconvenience—and an unnecessary apprehension of contingent misfortunes, rise to my memory as connected with my vegetable diet, although they may have been entirely the result of the disorder and not of the cure. Be this as it may, with this illness I bid farewell both to disease and medicine, for since that time, till the hour I am now writing (he had reached 36 years) I have enjoyed a state of the most robust health, having only had a complaint of occasional headaches or stomachic affections when I have been long without taking exercise, or have lived too convivially—the latter having been occasionally, though not habitually, the error of my youth, as the former has been of my advanced life.

My frame gradually became hardened with my constitution, and being both tall and muscular, I was rather disfigured than disabled by my lameness. This personal disadvantage did not prevent me from taking much exercise on horseback, and making long journeys on foot, in the course of which I often walked from twenty to thirty miles a day without fatigue. Wood, water and wilderness had an inexpressible charm for me.

His biographer adds,

He partook profusely in the juvenile bacchanalia of that day, and continued . . . down to the time of his marriage. . . . No man in mature life was, however, more habitually averse to every form of intemperance. He could, when I first knew him, swallow a great quantity of wine without being at all visibly disordered by it, but nothing short of some very particular occasion could ever induce him to put this strength of head to a trial, and I have heard him say many times: “Depend upon it, of all vices, drinking is the most incompatible with greatness.”

He wrote to his son:

Even drinking what is called a certain quantity every day, hurts the stomach.

If, as a young man, he followed the convivial habits of those about him, he had no vices. He used tobacco very moderately, but at fifty-four he wrote:

I have given up cigars and have no wish to return to the habit.

It was when he entered on his life's work that he fully appreciated his health and strength. He knew the need for temperance in meats and drinks and for muscular exercise, and until the avalanche of debt plunged him in ceaseless toil with his pen, he maintained both.

He did most of his literary work before breakfast and this became his chief meal. Says Lockhart:

No fox hunter ever prepared himself for the field with more substantial appliances. His table was always provided, in addition to the usually plentiful delicacies of a Scotch breakfast, with some solid article, on which he did most lusty execution—a round of beef—a pasty, such as made Gil Blas' eyes water, or, most welcome of all, a cold sheep's head. . . . A huge brown loaf flanked his elbow. . . . But this robust supply would have served him in fact for the day. He never tasted anything more before dinner, and at dinner he ate sparingly."

Sir Walter's financial difficulties began when he was forty-one, and between these and his ambition to establish a magnificent house at Abbotsford, he found himself led into an intemperance in work that sorely tried even his extraordinary powers. His literary labor, large as it was, was but a part of his daily work. That was disposed of by early rising, before breakfast, and at odd moments.

The immense strain of Scott's double or quadruple life as sheriff and clerk, hospitable laird, poet, novelist and miscellaneous man of letters, publisher and printer, though the prosperous excitement sustained him for a time, soon told upon his health.

At the age of forty-five he was visited "for the first time since his childish years with a painful illness." His pushing of "his liberties with a most robust constitution to a perilous extreme while the affairs of the Ballantynes were laboring" had brought their penalty. Four years before he had advised Mr. Ballantyne:

You must positively put yourself on a regimen as to eating, not for a month or two, but for a year at least, and take regular exercise. . . . I know this myself, for if I were to eat and drink in town as I do here, it would soon finish me, and yet I am sensible I live too genially in Edinburgh as it is. I take enough of exercise and enough of rest, but unluckily they are like a Lapland year, divided as one night and one day. In vacation I never sit down; in the session time I seldom rise up.

A cramp in the stomach, which, after various painful visits, as if it had been sent by Prospero, and had mistaken me for Caliban, at length chose to set fire to its lodging like the Frenchmen as they retreated from Russia.

For the inflammation thus set up "bleeding and blistering was the word; and they bled and blistered till they left me neither skin nor blood."

To aching eyes each landscape lowers,
 To feverish pulse each gale blows chill;
 And Araby's or Eden's bowers
 Were barren as this moorland hill.

"Rob Roy" was written this same year, and,

With returns of his cramps it had been a "tough job"—for lightly and airily as it reads, the author had struggled almost throughout with the pains, or the depressing effect of the opium taken for their relief. Calling on him one day to dun him for copy, James Ballantyne found him with a clean pen and a blank sheet before him, and uttered some rather solemn exclamation of surprise. "Ay, Ay, Jemmy," said Scott, "'tis easy for you to bid me get on, but how the deuce can I make Rob Roy's wife speak, with such a curmurring in my guts?"

He struggled to recover his loss of health, and the next year writes:

I have taken hard exercise with good effect and am often six hours on foot without stopping or sitting down.

But at forty-seven his health was still "very totterish." His last attack of colic ended in jaundice,

so that I might sit for the image of Plutus, the god of specie, so far as complexion goes. . . . If I had not the strength of a team of horses, I could never have fought through it, and through the heavy firing of medical artillery, scarce less exhausting—for bleeding, blistering, calomel and ipecacuanha have gone on without intermission.

The following year his health seemed quite restored. As a boy he "climbed like a wild cat" and his venturesomeness remained, for he writes in his journal:

Please God, I will be on the roof of the old Abbey (Melrose) when the scaffolding is up.

At fifty his favorite exercise was in wielding the axe, and none of his woodmen excelled him in bringing down a tree with the fewest possible strokes.

In 1825, in the midst of apparent prosperity, he was plunged by the failure of the publishing firm with which he was connected, into the worry and Herculean labors of trying to pay his creditors their due of \$750,000. Under this added strain he felt keenly any signs of bodily failure. Reminiscently he writes:

My early lameness considered, it was impossible for a man to have been stronger or more active than I have been, and that for twenty or thirty years. Seams will slit, and elbows will out, quoth the tailor; and as I was fifty-four 15 August last, my mortal vestments are none the newest.—Bodily health is the mainspring of the microcosm. . . . What poor things does a fever fit or an overflowing of bile make of the master of creation.—What a detestable feeling this fluttering of the heart is! I know it is nothing organic, and that it is entirely nervous; but the

sickening effects of it are dispiriting to a degree. Is it the body brings it on the mind, or the mind that inflicts it on the body? . . . As to body and mind, I fancy I might as well inquire whether the fiddle or fiddle-stick makes the tune.

During the following winter 1826–27, Sir Walter suffered great pain, but he was as stout of heart as any of the heroes of his romances, and, the following year, he writes:

There is a touch of the old spirit in me yet, that bids me brave the tempest—the spirit that in spite of manifold infirmities (of my childhood) made me a roaring boy in my youth, a desperate climber, a bold rider, a deep drinker, and a stout player at single stick, of all which valuable qualities there are now but slender remains.

At fifty-eight came the first stroke of apoplexy from which he quickly recovered, but other attacks soon followed, and the giant who, as a young man, “could lift a smith’s anvil with one hand—by what is called the horn,” and who once fought three highwaymen for an hour, found himself “if not quite unable to write” yet “unfit to do it. . . . A total prostration of bodily strength is my chief complaint. I can not walk half a mile. There is besides some mental confusion.” At sixty came a more severe shock, “the crowning blow” which was followed by his death in the ensuing year.

In the years of his physical perfection Scott

had a fresh, and brilliant complexion. His eyes were clear, open and well set, with a changeful radiance, to which teeth of the most perfect regularity and whiteness lent their assistance, while the noble expanse and elevation of the brow, gave to the whole aspect a dignity far above the charm of mere features. His smile was always delightful. . . . His figure, excepting the blemish in one limb, was eminently handsome; tall, much above the usual standard, it was cast in the very mold of a young Hercules; the head set on with singular grace, the throat and chest after the truest model of the antique, the hands delicately finished; the whole outline that of extraordinary vigor, without as yet a touch of clumsiness.

The sermon on health preached in his life by Waverly needs no commentary. Like all really great men, he was fully aware of the preciousness of his physical powers. Only six years before his death he writes:

I have perhaps all my life set an undue value on these gifts. Yet it does appear to me that high and independent feelings are naturally, though not uniformly or inseparably connected with bodily advantage. Strong men are usually good humored, and active men often display the same elasticity of mind as of body.

Carlyle, not without some warrant, bitterly scored his abuse (a conscious abuse) of his powers for the purpose of setting up a great house, but had the publishing concerns in the failure of

which he was involved been more carefully conducted, he would never have been shouldered with the extra worry and work which hastened his bodily dissolution. Had he been less strong morally and refused to shoulder his enormous weight of debt it had gone differently with his health of body. The abuse of health for mere accumulation of earthly goods and earthly repute is to be condemned, but the shortening of one's life to the end that others may have their rights and their just dues, marks the man as the hero, and the greater the bodily gifts which he sacrifices the greater his heroism. If Scott sinned in taxing his body unnecessarily for attaining wealth and prosperity he made up for it by the greater gift of all his powers to make good the results of commercial errors in which he shared only in name. In meeting the claims of his creditors "he paid the penalty of health and life." He was as heroic in soul as in body, and the greater, because of the greatness of his bodily sacrifice.

EUGENICS OF THE NEGRO RACE

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THE problem of *eugenics* is receiving much attention from students of sociology at the present time. The future welfare of society depends very largely upon perpetuating and carrying forward the best characteristics derivable from physical heredity and social environment. The application of eugenics to the colored race of the United States suggests several new and interesting lines of inquiry.

A study of the number of children, contributed by the fifty-five colored teachers in Howard University, Washington, D. C., throws an interesting sidelight on the question of eugenics as it affects the negro race. Howard University is an institution for the higher education of the negro, comprising a student body of over fifteen hundred. The negro members of the faculty maintain, on the whole, perhaps, a status as high as any other group of colored people to be found in the United States. The present study is limited to the teachers of the academic faculties, as they constitute a coherent social entity, whose life focuses about the institution.

As outgrowth of sudden change of condition due to the Civil War, the negro has developed a small upper class with a wide fissure between it and the great mass life of the race. There are about fifty thousand negroes belonging to the professional class, who earn a livelihood by some form of intellectual endeavor; while the great bulk of the race lives mainly by manual exertion. All social stratification rests ultimately upon occupation. The negro has no considerable middle class, such as is found in well-regulated societies, which shades imperceptibly in both directions. According to the occupational test, the demarcation between the professional and laboring classes of the negro is as sharp as a knife-cut line.

It becomes a matter of sociological interest to know how far this upper class is self-sustaining through its own reproductivity. I have therefore undertaken to make a study of race eugenics in so far as this particular group is concerned. In the fifty-five families from which these teachers were derived, there were 363 children, or an average of 6.5 for each family. On the other hand, these fifty-five teachers who have passed from the lower to the upper section of negro life, have, so far, contributed

only 37 children, or an average of .7 for each potential family involved. Of this number there are 41 males, 14 females; 22 are married, and 33 are single; the number of children for each family so far formed is 1.6; the largest number of children in any family is 6; four of the families are barren and four have one child each. The average age of the single members is over 32 years. This strongly indicates that the upward struggle defers the age of marriage to a time when only limited progeny might be expected. Considering all the probabilities in the case, it seems to me entirely likely that these fifty-five potential families, when the whole record is in, will not produce more than an average of two children to each family, while the fifty-five parent families, under the old régime, gave rise to 363 children. The new issue will scarcely produce sufficient progeny to perpetuate its own numbers.

There is always a certain sort of social restraint, in the case of an individual advancing from a lower to a higher level of life. The first descendants of foreigners in this country have a lower birth rate than any other element of our population. The intolerant social environment created by the white race may also produce a strong deterrent influence. Animals, in captivity or under restrained environment, do not breed as freely as when placed under free and normal surroundings. The educated negro, especially when submerged in a white environment, is under a sort of social captivity. The effect of this psychophysical factor upon reproductivity awaits further and fuller study, both in its biological and psychological aspects.

From a wide acquaintance with the upper life of the negro race, under wide variety of conditions and circumstances, I am fully persuaded that this Howard University group is typical of like element throughout the race so far as fecundity is concerned. The upper class is headed towards extinction, unless reinforced from the fruitful mass below. It is doubtless true that the same restraining influence is exerted upon the corresponding element of the white race. But as there is not the same sharpness of separation between the social levels, nor such severe transitional struggle, the contributing causes do not perhaps operate with the same degree of intensity.

The prolonged period of education delays the age of marriage. The negro during the first generation of freedom acquired his education at a later period than the white children and by reason of the hard struggle he has had to undergo, his scholastic training was completed at a somewhat advanced age. The high standard of living, which the professional negro feels he must maintain, still further delays the age of marriage. A

single illustration will serve to clarify this point. I half-jocularly asked one of our bachelor instructors, who has passed beyond his fortieth birthday, why he did not take unto himself a companion and help-mate. His reply was that his salary was not sufficient to allow him to support a family in the style and manner which he deemed appropriate. My reply was: "If your parents had been constrained by like consideration, you would probably not be in existence." His father was a laboring man with a family of eight children. It was the opinion of Grant Allen, the eminent English literary and scientific authority, that the human race would become extinct if all females deferred marriage beyond the age of twenty-six.

The conscious purpose of race suicide doubtless contributes somewhat to the low birth rate. There are some of sensitive and timid spirit who shirk the responsibility of parenthood, because they do not wish to bring into the world children to be subjected to the proscription and obloquy of the negro's social status.

Will this tendency, which threatens the extinction of the higher element of the negro race, continue to operate in the future with the same degree of intensity as at the present time? Probably not. The first generation after slavery was subjected to the severe strain and stress of rapid readjustment. The sudden leap from the lower to the upper levels of life was a feat of social acrobatics that can hardly be repeated under more orderly scheme of development. The life of subsequent generations will be better ordered, and therefore we may expect that the resulting effect will be seen in the family life. The birth rate of the mass of the race is not affected by like considerations. They feel little or nothing of the stress and strain of the upper class, and multiply and make merry, in blissful oblivion of these things. The rate of increase of the upper class is scarcely a third of that of the bulk of the race, as is clearly indicated by the relative prolificness of the Howard University faculty as compared with that of their parents. The higher or professional class in the negro race will not be recruited from within its own ranks, but must be reinforced from the great mass below. This will produce healthy current throughout the race which will serve somewhat to bridge the chasm produced by the absence of a mediatory class.

The whole question suggests the importance of a more careful and extended study in this field of inquiry which is as fruitful as any other in its far-reaching effect upon the general social welfare.

THE PRINCIPLES OF HUMAN PROGRESS

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LIFE is a phenomenon manifested only by and through protoplasm, a jelly-like substance having the physical properties of a liquid, forming the essential basis of all plants and animals. This protoplasm is a carbon compound, consisting of extremely complex molecules, which are continually in a state of change; yet it maintains its essential characters from generation to generation, and is, in a large sense, one of the most permanent substances in the world. In spite of the conservatism of this changeable substance, evolution has taken place. In the course of millions of years, millions of species of animals and plants, each having its own particular place in nature, have come into existence. All these species, and the divisions of species which we call varieties or races, have distinctive characters, which may with rare exceptions be observed in dead and preserved specimens. Such characters we call *morphological*. There are, however, other characters, the description of which is the function of physiology and psychology, which are dynamic rather than static; which can not be seen in preserved specimens, though they may often be inferred. Characters of this latter class are exhibited in the *reactions* of the organism to external and internal stimuli. Even such a regular process as the beating of the heart requires a stimulus, though this is furnished automatically.

When we regard vast periods of time, evolutionary progress can be readily appreciated; change seems to be the rule. Morphological, physiological and psychological characters have all gone into the melting-pot, to emerge in new forms and phases. Progress and life appear to be almost synonymous. Yet we find, on investigation, that the *tissues* out of which living things are made are extraordinarily permanent. So also are the *determiners*, the units in inheritance; while many species have existed untransformed for enormous periods.¹ The correlation of

¹ Pearl, quoting Loeb, states that Walcott found "that pre-Cambrian annelids, snails, crustaceans, and algæ were in many cases so like forms living to-day as to belong to the same genera." (*American Naturalist*, Feb., 1917, p. 90.) This is, of course, altogether incorrect.

evolutionary progress with *human* progress appears increasingly doubtful; the processes may not even be of the same nature. Even in those cases, such as the evening primroses of de Vries, where "mutation" is rampant, we find on analysis no real resemblance to human progress. The phenomena appear to need different designations, for which the current language is rather inadequate.

Forgetting the slow sweep of evolution, and dealing with short periods of time, we find that *species* are essentially static. Species, as we find them, *are*: they are not in process of becoming. As species, they ordinarily know nothing of progress. Man himself, in a wild state, remains unchanged for ages. The remoter regions of the Amazon harbor tribes who live like animals of the forest, and have no history. For them, one epoch, one century, is like another.

On the other hand, the *individual* is intensely dynamic. He is continually in process of becoming. For him, progress never ceases, though its rate rapidly decreases from the beginnings of life. The years, the days, all have their history, their succession of *different* events. For different individuals, the character and amount of this progress will differ, but none can escape the procession of events represented by physical growth, mental development coming from experience, and so forth.

Now we see that physiological characters, *regarded as specific*, have no more relation to progress than morphological ones. Lester Ward used to argue that physiology is not a dynamic science, because it is as it were an aspect or consequence of morphology. The *go* of the living thing is an individual *go*, not a specific one. It is not part of evolution.

Whence, then, comes human progress? How is it that the *species* *Homo sapiens* has taken on the dynamic features of the *individual*; has almost become a vast and long-lived individual? The various readjustments shown by animals and plants under new conditions do not offer parallel phenomena. They all represent movements toward new positions of stability. Human progress, instead of leading to stability, carries with it a principle of acceleration.

Mankind was well embarked on this new adventure before it was realized what was happening. It is not so very long ago that the idea of *necessary* progress was foreign to us. There was, indeed, a sense of *change*, and it was supposed that our species had fallen from some high estate. Eden knew no progress, it was a place of perpetual bliss, undisturbed by reformers. The fall was due to a centrifugal disturbance, diverting man

from his natural accustomed round. Once the circle had been broken, there was no return to the old state of affairs, and as a penalty for refusal to conform, conformity became forever impossible. The burden of sin could never be lifted from the species, but worthy individuals would pass after death into a sphere where the old uniformity, the old monotony, reigned once more. With the enormous growth of stored knowledge following the invention of printing and the revivification of science, together with the rapidly increasing exploration of every part of the world, progress became increasingly rapid. It began to be apparent that man had not merely lost his way; *he was going somewhere!* The appreciation of this stupendous fact was bound to change the whole intellectual and moral outlook. Social progress, really analogous to individual progress, had become the rule. Reformers were no longer trying to reverse the current, or to find a way out of the consequences of our first parents' disobedience. Joyfully, they took up the task of *raising* the species to that degree of maturity to which it was entitled. Whether, like a person, it must some day die, need not be considered. It was in any event destined to live far into the future, and to develop in ways beyond imagining.

It is interesting to note the gradual diffusion of the new point of view, even so recently as during the nineteenth century. The earlier reformers of that period were largely concerned with the removal of disabilities, with remedies for existing evils. Their main thought was to cure the patient, who was certainly in need of it. As the years wore on, the dominant attitude gradually shifted. The doctrine that the best government is that which makes itself least necessary was abandoned. *Laissez faire* gave way to *constructive* ideals, and while it remained necessary to combat evils, *development* became the leading purpose.

Progress beget progress. Each move forward disclosed fresh fields of opportunity, and those who neglected them found themselves abandoned by the moving social mass. To keep up with the procession was necessary, in order to retain the benefits of social life. Progress was no longer the fruit of idealism, it had acquired an ever increasing momentum of its own. Unfortunately, the speed of the several parts was extremely unequal, and serious dislocations resulted. Conservatives tried to hold back the advanced groups, radicals to spur on those who lagged. Their diagnosis of the trouble was exactly opposite. Yet in a sense both were right.

Thus the modern reformer, the modern progressive, is like

a man in a chariot pulled by many horses. He can not stop, he does not wish to—all he can do is to attempt to control the animals. This one must be held in, this encouraged by the whip; this held to the road, lest it upset the vehicle. He no longer says, with the philosophers of a mechanistic school, "let them go, they will go when they must!" He feels more and more his responsibility, and the need for controlling the processes which he can not and usually would not stop. For his guidance he appeals on the one hand to science, to the facts with which he has to deal—the structure of the vehicle and the nature of his beasts—on the other to his idealism, his innate feeling concerning the nature and proper destiny of man. He may make mistakes, but he knows that damnation equally with salvation lies on the road before him, and that he, and he alone, can determine which it shall be for him and his. Yet he feels that he is not alone in a deeper sense; he prays to his God, confident that there is something in the very structure of the universe which will uphold his arms.

Where is he going? Is there some haven of realized ideals, some ultimate goal of social stability and perfection? He does not know, but the wind blows in his face, and the dawn of a new day lights the eastern sky.

SOME OF THE NEWER CONCEPTIONS OF MILK IN ITS RELATION TO HEALTH

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MILK has been regarded from the earliest times as a most important article of food and, although little was known as to its chemical composition previous to the eighteenth century, the ancients attributed many and peculiar hidden virtues to it.

In 1911 ten billion gallons of milk were produced in the United States, one quarter of which was consumed as milk and the remaining three quarters as butter and cheese. Although milk and milk products constitute about 16 per cent. of the average dietary in this country, the average daily consumption of milk per capita is but 0.6 of a pint. The milk of goats and asses has found but little favor on this continent; in Asiatic and European countries, however, it is a common article of diet, particularly goat's milk.

The chemical composition of milk is such as to make it a perfect food for infants, and at the same time an ideal culture medium for almost all kinds of bacteria. Sanitarians have in recent years impressed upon the minds of consumers the great dangers arising from the use of unclean and impure milk, and justly so; but in the slow and gradual readjustment of the milk production problem the intrinsic value of milk has often been lost sight of, and in fact prejudice has too often superseded what once was fondness for this product. As numerous publications on this subject, both popular and scientific, are appearing almost constantly, little attention will be given in this paper to the sanitary phase of milk production. It is to be understood, however, that in the discussion of the value of milk as a food pure and wholesome milk alone is given consideration.

There is a widely prevalent notion that the average amount of meat consumption per capita in this country is far beyond what it should be, and there are many who object to meat in any form or amount. These objections are based on the following contentions: first, that the high protein content of meat

subjects the digestive and excretory organs to a heavy burden; second, that as real animal food the consumption of meat necessitates the destruction of the animal itself, and finally that the cost as a rule is out of all proportion to the value received, especially in times of scarcity. It is not within the province of this paper to express a conviction as to whether meat is a necessary or even desirable article of diet. Indeed, the arguments offered both for and against meat and meat products are such as to render a final judgment most difficult.

On the other hand, milk is without doubt the most important of all foods, and must be regarded as an absolute necessity in the early life of all mammalian species, in spite of the fact that here and there proprietary infant foods have been employed with at least some measure of success.

The value of mother's milk to the young infant is too well known to require much comment. However, the growing tendency to substitute artificial for breast feeding is an indication that the subject of infant feeding is not taken as seriously as it deserves. Mother's milk is superior to any and all substitutes, as abundant statistical evidence shows. Furthermore, it has always been the only natural food for the very young.

Next in importance to mother's milk is cow's milk. While the protein content of the latter is much greater than that of mother's milk, methods of modifying it by dilution with water and the addition of milk sugar and cream have in recent years done much to enhance the value of cow's milk in infant feeding, and in fact so successful has this practice become that in the opinion of many physicians and dietitians it is rated as being almost equal in nutritive value to mother's milk.

It is the purpose of this paper to impress upon its readers the importance of milk as a daily article of diet, not only for the very young, but for children of all ages and for adults. If the true value of milk as a stimulator of growth and vigor throughout the developmental period were known and fully appreciated, the number of underdeveloped and anemic children would be greatly reduced. Too often milk feeding for the infant is regarded merely as a necessity, because it is the only food that is tolerated by the easily deranged digestive organs, as experience has long shown. When an age is attained at which other foods are apparently borne as well as milk little effort is made to continue milk feeding, especially if there is any indifference or reluctance on the part of the child.

It is a well-recognized fact that, while the chemical com-

position and physical properties of mother's milk and modified cow's milk are such as to render them an ideal food for young infants, the percentage of solids, particularly sugar, protein and fat, is too small to constitute a complete diet for older children and for adults. Hence, milk must be considered as only a part of a dietary regime after early infancy, except for the sick and convalescent. The amount and kind of other foods required vary with the individual and in a large measure with his or her occupation. For example, a man at hard labor would be required to consume large quantities of milk, in order to obtain sufficient nourishment as compared with a person living a very quiet and sedentary life. However, the benefit derived from the consumption of milk is in all probability not proportionate to the amount of milk taken daily.

One of the greatest modern exponents of the use of milk as a part of the daily diet was Metchnikoff, who by his public utterances and numerous publications stimulated new interest in this subject. Metchnikoff's observations and theories pertained only to so-called "sour milk" and "sour-milk products," and although opinions may differ as to whether or not his explanations of the health-giving properties of sour milk are based upon sound logic, his conclusions must, in a measure at least be accepted. A review of some of Metchnikoff's observations may be of particular interest here. The following excerpts are taken from his most fascinating book, "The Prolongation of Life" (G. P. Putnam's Sons, New York, 1907, translated).

In early biblical times the use of both sweet and sour milk is recorded. From the remotest antiquity a food known as "Leben raib," which is a sour milk prepared from the milk of buffaloes, kine or goats, has been employed in Egypt. A similar preparation known as "yahourt" has long been familiar to the people of the Balkan States. In Algiers the natives use a kind of "Leben" which differs somewhat from the Egyptian product. Soured milk is consumed in great quantities in Russia in two forms, namely "prostokwacha" which is a spontaneously soured and coagulated raw milk, and "varanetz" which is a product obtained by the souring of boiled milk with yeast.

Milk constitutes the chief food for many of the natives of tropical Africa. As in the other countries mentioned, the milk is consumed as a curdled, soured product. Meat is eaten only on rare occasions.

Koumiss is the well-known national beverage of nomadic

tribes in Asiatic Russia. It is prepared from mare's milk, while kephir, which is the native drink of the Caucasus, is the fermented product of cow's milk. Both koumiss and kephir contain, besides acid-producing bacteria, yeasts which cause alcoholic fermentation, the alcohol content of the former being at times as much as one per cent. Matzoon is a milk in which lactic acid fermentation is interrupted at a certain point. It is often tolerated better by irritable stomachs than ordinary milk, koumiss or kephir. It is a highly esteemed and universal beverage of the Armenians, and may be prepared easily by the addition of a small amount of matzoon stock to boiled milk that has been cooled to 100° F.

Coincident with the general use of soured milk in certain countries is the fact that many of the inhabitants live to be very old. This is particularly true in Bulgaria, where yahourth is the staple food. Many of the centenarians live chiefly on the milk diet. For example, Marie Priou, who died at the age of 158 years, is stated to have lived during the last ten years of her life entirely on cheese and goat's milk.

A certain laborer of Verdun in France who died at the age of 111 years ate nothing but unleavened bread and skimmed milk. Another French centenarian who attained 110 years lived on bread and milk food alone. Thense Abalva, a native of the Caucasus, who is at least 150 years old, subsists entirely on barley bread and butter milk. Another apparently well-authenticated example is that of an American eighty-four years old who owes his health to the curdled milk which he has taken for the last 40 years.

While there are comparatively many centenarians on the Balkan Peninsula, in Persia, Arabia, in the Caucasus, and in other countries where sour milk is the chief article of diet, or at least where it is consumed regularly in large quantities, there are relatively few persons who attain this age in the countries where sour milk consumption has not become a national custom.

According to Metchnikoff, sour milk is of great merit because of the lactic acid and of the acid-producing bacteria which it contains in enormous numbers. The ingestion of sour milk has a direct influence on the bacterial processes which take place in the digestive tract, particularly in the large intestine. A diet containing much albuminous food is conducive to marked putrefactive changes in the large intestine. Sour milk or the acid-producing bacteria decrease or prevent this putrefaction, which is the result of ordinary microorganisms that are

normally present in the intestine. In other words, intestinal putrefaction, which is caused by certain so-called "putrefactive" organisms, is a process which is of common occurrence in man, especially on an ordinary mixed diet. This process is in itself harmful on account of the injurious nitrogenous bacterial products that are constantly formed and absorbed from the intestine, this harmful influence being what is commonly called "auto-intoxication."

According to Metchnikoff these putrefactive products, although not strongly toxic in small amounts or when administered for only short periods, work permanent injury to the body when they are being absorbed constantly for months and years. In fact so profound is this baleful influence that it may be considered as one of the important causes of permanent hardening of the arteries, or arteriosclerosis, and indeed premature old age. Acid is one of the agencies which prevents these putrefactive changes in the intestine. It controls the bacterial activities in such a way that only such organisms as are harmless are permitted to increase in appreciable numbers. More recently Metchnikoff has advocated also the use of acid-producing bacteria for the same purpose, claiming that when they are taken into the digestive tract they become acclimated in the intestine and in their continued development suppress the putrefactive bacteria. Many different brands of these acid-producing bacteria are being produced and sold in the form of powders, capsules, etc. The active principle in all of them, however, is the organism known as *Bacillus bulgaricus*, to which in particular most of the sour-milk products of the Balkan and other states owe their peculiar properties.

Bacillus bulgaricus is a unique organism in more respects than one. In a medium containing grape or milk sugar it exerts powerful fermentative properties which results in the production of large amounts of acids, but no gases. Ordinary milk is a particularly favorable medium for this organism, and the acidity produced may reach as high as 2.5 to 3 per cent. This is not at all surprising, as milk contains from four to five per cent. of milk sugar. Very few organisms are able to develop or even live in such an acid medium, and this is especially true of the putrefiers.

Metchnikoff's views have met with no inconsiderable amount of opposition. On the other hand, they have in the main been accepted by many, as is evidenced by the large output of different Bulgaria products sold usually in the concentrated dry form as tablets or powders. These products in many

instances are claimed to possess great remedial properties, as, for instance, in toxic diarrheas, constipation, intestinal putrefaction, arteriosclerosis, and even rheumatism, intestinal tuberculosis and typhoid fever. They have been advocated and used for sprays in diphtheria and other mouth and throat infections. The preparation of sour milk with the aid of these tablets or powders has also become a very common practice in recent years, and there can be no doubt but that in many instances the use of sour milk so prepared has been attended with success.

That the value of these *Bacillus bulgaricus* products has been grossly exaggerated can hardly be questioned, and particularly in so far as the remedial properties of the commercial powders and tablets are concerned. On the other hand, the consumption of sour milk, as advocated by Metchnikoff and his followers, has much to commend it. The value of the sour milk does not lie in the acids or the acid-producing bacteria, however, as will be shown in this paper, but in milk as such, irrespective of the character of the milk as to whether it is sweet, sour, whole, skimmed, raw or pasteurized milk.

In 1892 Rovighi showed that a kephir diet caused a great reduction in the ethereal sulphates (intestinal putrefaction products) in the urine, and of indol in the intestine. He believed that acids played an important rôle in suppressing intestinal putrefaction, but could not substantiate this by practical experiment. In the same year Winternitz demonstrated that milk strongly inhibits putrefaction, and held that this was due to the lactose, and not to the acids resulting from its decomposition by bacteria. The following year Schmits brought about a marked reduction in intestinal putrefaction products by feeding lactose. These observations have been repeatedly verified by other investigators.

The intestinal contents of the new-born infant are free from bacteria and other microscopic organisms. Very soon after birth, however, bacteria make their appearance and in the course of but relatively few hours become very abundant. The nature of these microorganisms is determined by the food of the infant, as was shown by Tissier and others. In the normal breast-fed child an organism first observed and described by this writer, and known as *Bacillus bifidus*, is present to the exclusion of all other forms. This organism readily attacks milk sugar without gas production, but has no putrefactive properties; in other words, it does not decompose albuminous substances with the formation of injurious products.

A change from breast- to bottle-feeding is accompanied by a change in the character of the intestinal flora. The simplified type is transformed into a mixed flora in which another organism, *Bacillus acidophillus* of Moro, assumes much prominence. When the diet becomes more varied by the addition of other foods, as, for example, egg and bread, the intestinal flora becomes still more complex and gradually assumes the character of that of the adult.

The bacterial flora of the intestine of man and animal may in a very large measure be determined by the diet. We have repeatedly shown that the bacterial contents of the intestine of the white rat may be transformed from the mixed to a simplified flora by the addition of milk to the regular diet. In the course of one to three days a flora is established which resembles that of an infant subsisting entirely on milk. When milk sugar is fed along with the milk, or alone in sufficient amount, the typical *bifidus* flora of the breast-fed child is obtained. The same transformation may be brought in the intestine of man, though relatively larger amounts of milk and of milk sugar are required. Torrey demonstrated that the feeding of a high caloric diet (milk and milk sugar) to typhoid patients tended to reduce the putrefying types of bacteria and to encourage the so-called "acidophilic" organisms which characterize the intestinal flora of infants subsisting entirely on milk.

The favorable influence of milk on the bacteria of the intestine is due largely to the lactose or milk sugar in the milk, which at times contains as much as six per cent. of the carbohydrate. The harmless and perhaps even beneficial bacteria of the *Bacillus bifidus* type readily attack milk sugar, and in the presence of this sugar find their optimum environment in the intestine, and develop so readily as to suppress or crowd out the harmful or putrefactive forms which find their most favorable cultural conditions in a medium rich in nitrogenous matter and poor in carbohydrate.

The preponderance of the sugar-loving type is not due to the acids that are produced in the decomposition of the sugars, nor can the reduction or disappearance of the putrefactive forms be ascribed to the presence of free acids in the intestine, for, except when they are introduced into the intestine in large amounts, acids rapidly disappear through absorption by the intestinal wall or by neutralization. This has been shown repeatedly. Metchnikoff's contention that the use of sour milk and milk-souring bacteria is of benefit to the consumer because of the action of the acids that are thereby introduced into the

intestine is not supported by direct observation. The suppression of putrefactive processes is brought about by influences other than acids.

It has likewise been shown again and again that the ingestion of even very large numbers of *Bacillus bulgaricus* with or without milk does not lead to an implantation and acclimatization of this organism in the intestine. This bacterium, which is of such wide distribution in nature, and especially in different kinds of sour milk, is unable under any and all conditions to establish itself in the intestine of man or animal. However, an organism (*Bacillus acidophilus*) which in many respects is closely allied to *Bacillus bulgaricus* is a common inhabitant of the intestine. Like *Bacillus bifidus*, which it closely resembles in appearance and physiological properties, *Bacillus acidophilus* is comparatively rare in the intestine during an ordinary mixed diet or one rich in protein. The addition of milk or of milk sugar to the diet encourages the development of this organism in the intestine, and at times to such an extent that all other forms are apparently excluded. This bacterium has often been mistaken for *Bacillus bulgaricus*.

That the so-called *Bacillus acidophilus* is not the same as the other may be shown readily by feeding milk which has been sterilized. The same transformation takes place in the intestine as when unheated sour milk is consumed. The ingestion of milk in any form, sweet, sour, raw or sterilized, leads to this same result. On the other hand, the feeding of even very large numbers of *Bacillus bulgaricus* in water, without milk or lactose, does not result in the implantation of the ingested organism, and the intestinal flora remains unchanged. It may be said, therefore, that diet is an important factor in determining the character of the intestinal flora, and that foreign bacteria find it difficult and as a rule impossible to establish themselves in the intestine. Bacteria which are of the strictly disease-producing type are, of course, not to be included in this category.

Aside from the significant fact that milk when taken in sufficient amount regulates the biochemical changes which take place in the lumen of the intestine, milk as such constitutes a most important article of diet. The value of milk as a food lies not only in its peculiar composition, that is in the proteins, fat, sugar, inorganic salts and other well-known ingredients, but also in certain demonstrable but as yet vaguely-defined substances known as "vitamins" or "accessories." These vitamins belong to a group of agents which are widely distributed

in nature, and which are now regarded as an essential factor in diet. Let us next consider some of the evidence which supports the assertion that milk possesses unique dietary properties.

Hopkins clearly demonstrated that the feeding of very small quantities of milk to rats which had been subsisting on a diet that was not conducive to normal growth brought about a rapid gain in the weight of the animals. Osborne and Mendel in their valuable experiments on the growth of animals have for several years been employing so-called "protein-free milk" as an indispensable ingredient of their basic diet to which certain isolated food substances (proteins, amino acids, etc.) are added. They state that "no artificial imitation of this natural mixture (milk from which all protein had been removed) has been devised to replace it satisfactorily for considerable periods of time." The weight and health of adult rats has been maintained for many months on a ration consisting of protein, starch, sugar, protein-free milk and lard. Young animals kept on this mixture decline after a definite period. If butter fat is substituted for the lard, however, growth is resumed. Hence, they consider the fat as one of the important food substances in milk. The fat is in all probability of much importance on account of the vitamins which it holds, and which are fat-soluble, as contrasted with the water-soluble accessories present in the protein-free milk. Ordinary skim milk contains both the fat-soluble and water-soluble accessories.

Numerous milk-feeding experiments have been conducted on young animals of different species, but few have been of much scientific value, owing to incomplete data and to a lack of adequate control of the experiments. The following investigation is one in which the writer was for several years engaged, and in which the results were a source of surprise even to those who were most intimately associated with the experiments.

THE INFLUENCE OF MILK ON GROWTH AND MORTALITY

Numerous experiments were conducted on young chicks. When one to two days old the chicks were taken from the incubators, divided into uniform groups, usually six, each group containing from 25 to 60 chicks. Half of the lots, for example 1, 3 and 5, were supplied with milk in a shallow galvanized stew pan covered with a meshed wire, while the remaining lots, 2, 4 and 6, received no milk. Both the general groups of

chicks were constantly provisioned with a standard chick feed and dry mash. The milk was kept before the milk-fed chicks constantly. It was supplied as a rule as skimmed milk, rarely as whole. In some of the experiments sweet milk was employed, in others naturally soured, and in still others milk which had been soured by the *Bulgaricus bacillus* of Metchnikoff. In the preparation of the *Bulgaricus* product the milk was sterilized by live steam under pressure. Hence, both raw and sterilized milk was used in large amounts. Over five thousand chicks were employed in this investigation. The duration of the individual experiments was six to eight weeks.

In all of the experiments the milk-fed chicks were larger and in every respect appeared stronger and more vigorous than the corresponding control lots which received no milk. In a few instances the difference in the average weight of the two lots was almost 100 per cent. Furthermore, the combs of the milk-fed groups were redder, and the legs decidedly stronger, than those of the other lots. In one particular experiment, which was allowed to continue longer than the others, a marked difference was noted in the ages at which the males exhibited crowing propensities.

TABLE SHOWING THE INFLUENCE OF SOUR MILK FEEDING ON GROWTH
(Combined results with 1,498 chicks)

Number of Chicks	Gains per Chick at Completion of Experiments		
	Fed Sour Milk	No Milk	Difference
(1) 890.....	0.7 pound	0.43 pound	0.37 pound or 38.5 per cent.
(2) 608.....	0.79 "	0.46 "	0.33 " " 41.8 " "

That the growth-stimulating properties of milk are not confined to sour milk is clearly shown in the following summary of results on 375 chicks:

Combined averages:

	Gains per chick
Fed sour milk	0.48 pound per chick
Fed sweet milk	0.44 pound per chick
Given no milk	0.39 pound per chick

The results obtained with naturally soured and with *Bulgaricus* milk were practically the same, hence no definite figures are presented here. It should be said, however, that a slight preference was shown for the naturally soured milk, as compared with the sweet and with the *Bulgaricus* product.

In the chick-feeding experiments milk exerted a pronounced influence on mortality, no matter whether sweet, naturally soured or *Bulgaricus* milk was supplied. The following figures give the combined results obtained in eight different experiments with 1,125 chicks.

TABULATED RESULTS SHOWING THE INFLUENCE OF SOUR AND OF SWEET MILK ON MORTALITY

Sour Milk		Sweet Milk		Without Milk	
Number of Chicks	Deaths	Number of Chicks	Deaths	Number of Chicks	Deaths
375	65, or 17.3%	375.....	61, or 16.3%	375.....	114, or 30.4%

In two experiments not included in the above figures there was no mortality among the milk-fed chicks, while the loss in the control pens receiving no milk was 10 and 12 per cent.

The favorable influence of milk here shown can not be attributed merely to a regulation of the character of the intestinal flora, but is to be explained in a large measure on the basis of health and vigor production through the growth-producing and stimulating properties of the milk. Growth is a normal process in which metabolic activities are at their height and in which the body cells and tissues are printed to meet the requirements placed upon them. Resistance to inimical influences is stimulated and health is conserved.

Milk contains two important nitrogenous food substances, namely, casein and lactalbumin. Of these two proteins the lactalbumin is the more important in supplying the necessary material for growth and body maintenance, according to the researches of Osborne and Mendel. This is due to the fact that it contains certain chemical groups (amino acids of peculiar composition, as for example lysin) within its molecule which are not present in the casein. Whatever deficiency there is in these substances is more than counterbalanced, however, by the amount of casein present in milk (3 per cent.) as compared with the lactalbumin (0.5 per cent.). Osborne and Mendel found in their feeding experiments with white rats that to produce the same gain in body weight 50 per cent. more casein than lactalbumin was required.

The milk sugar (5 per cent.) and fat (3.5-5 per cent.) present in cow's milk also add greatly to the fuel value; furthermore, the various inorganic substances, particularly calcium, sodium and potassium salts, and the phosphates can not

be ignored. While all of these valuable constituents contribute their great share in making milk the most important of all foods, we must seek further for a full explanation of its real merits. We turn naturally to the so-called "vitamins," to which reference has already been made.

There are present in milk "vitamins" or "food accessories" of two orders. The one is fat-soluble and is therefore bound up in the butter fat. This agent is closely akin to the vitamin of egg yolk and of cod-liver oil. The other is water-soluble, and is present in milk from which the fat has been to a large extent or entirely removed. While opinion has differed as to the heat tolerance of these accessories, there is no doubt that both the fat- and the water-soluble vitamins withstand the heat of ordinary pasteurization, and that they are not completely destroyed even in the process of boiling for as short a period as 10 to 15 minutes. These facts are of much significance, since they have a direct bearing on the question of the relative food value of raw and pasteurized milk. Food accessories or vitamins are now regarded as being absolutely necessary in an efficient diet. Nutritional diseases like scurvy and beri-beri are known to be due to the continued and exclusive use of a diet, as, for example, canned foods and polished rice, from which the vitamins have been lost by excessive heating or the removal of certain parts of the food, as in the polishing of rice.

Considerable effort has been made in recent years to overcome the prejudice existing in the minds of most Americans against pasteurized or boiled milk. No one has done more to convince physicians and laymen that heating does not alter the food value of milk, and that it even improves the quality of milk which is not of a high standard from the standpoint of real sanitation, than Janet E. Lane-Claypon, who has devoted years to this problem. This author's recent book on "Milk and its Hygienic Relations" (Longmans, Green and Co., New York) presents an excellent résumé of the subject of milk in its various phases, and particularly the relative merits of heated and unheated milk. While milk in its relation to infant feeding is the underlying theme throughout the book, the data and discussions on the influence of heat may be applied as well in any movement to stimulate a more general use of milk in its various forms and for persons of all ages.

The time has come when raw milk from tuberculous cows must be regarded as a useless commodity. Such milk is used, however, by thousands of consumers daily, for a large amount of market milk to-day may be found by correct methods to con-

tain the bacillus of tuberculosis. The only real safeguard against possible danger from infected milk is proper heating.

Bang of Copenhagen has adopted and successfully carried out a system of rearing calves which come from tuberculous mothers on milk which has been boiled. The calves are taken away from the mother very soon after birth, and brought up on the heated milk on so-called "calf farms." These calves remain free from tuberculosis, and hence become a valuable addition to the newly selected adult herd, which should remain tubercle-bacillus-free. Similar methods have been followed in this and other countries, not only for the purpose of eliminating tuberculosis from a herd, but also to protect the calves against diseases like "scours" and contagious abortion. Professor V. A. Moore has strongly advocated the feeding of boiled milk to calves, though in one paper he states that a preliminary feeding with raw milk may be advisable.

The following facts are, to a large extent, taken from Miss Lane-Claypon's book: Finkelstein in a large number of observations on children having digestive disturbances concludes that "no definite distinction between the results obtained by feeding upon raw and boiled milk respectively could be detected." "Plantenga treated children with digestive troubles with both raw and boiled milk, and was unable to find any evidence of the superiority of either method of feeding."

In the important investigation of Park and Holt the results were much more favorable from the standpoint of the pasteurized than the raw milk. "Of 51 children who were fed on raw milk, 13 had to be transferred before the end of the period of observation to pasteurized." "Hohlfield published 8 cases of children suffering from various stages of malnutrition who were fed for the most part upon raw milk; some, however, received raw milk alternately with boiled milk." Numerous additional cases might be cited here in which heated milk possessed the same nutritional properties as the raw. It should be stated that the results which favor the heated milk may have been due to a slight extent at least to the bacteria and their products which were present and continued to be harmful in the raw milk.

Pasteurization of cow's milk is rapidly assuming more and more importance in this country. This is due largely to the growing recognition of the possible dangers which may lurk in milk which has not been produced and handled under the most sanitary conditions. It may be explained also on the ground that commercial pasteurizers are becoming more effi-

cient and reliable. Of these pasteurizers two stand out conspicuously as having special merit, the so-called "holding device" in which the milk is held for 20 to 30 minutes at 145 to 150° F., and the device by which the milk is heated at the pasteurization temperature in the package or bottle in which it is delivered. The last-named method has the distinct advantage that the milk can not become re-contaminated after the heating, except by the consumer himself. Pasteurization by this method is one of the best safeguards against milk-borne tuberculosis, typhoid fever, dysentery, septic sore throat and diphtheria. While certified and other high grades of milk are much less apt to contain disease microorganisms than the ordinary market milk, they can not be considered absolutely safe simply because they were produced under sanitary conditions, for there is always a chance of infection from an unrecognized tuberculous cow or from a human carrier.

The use of milk as a daily article of diet can not be too strongly advocated. It matters little whether it is whole, skim, pasteurized or raw, aside from the element of possible danger from harmful bacteria. Nor can too much be said of the nutritional value of cheeses which, we are told, are among the most valuable of our concentrated foods, and which, contrary to popular opinion, are well borne by the digestive and related organs, provided they are well masticated or prepared in a finely divided state before they are served as food.

Skim milk has always been regarded in this country as an almost useless commodity, and many thousands of gallons have been poured daily into the drainpipe. Quite recently, however, the feeding of skim milk to farm animals, particularly young swine and poultry, has fortunately become a general practise. But as food for man it has been not merely ignored, but shunned. This is made all the more apparent by the legal regulations which, because they require the conspicuous labelling of skim milk that is offered for sale, have tended to discourage the sale of this product. Skim milk contains almost the same amount of nutriment and so-called "accessories" as whole milk, the only difference being in the quantity of fat which by the skimming is reduced three to four per cent. All of the sugar, casein and lactalbumin, as well as the significant vitamins, inorganic salts and a small amount of fat are retained in the product commonly termed skim milk.

Skim milk should find its way into every home, at least for cooking purposes, and its use in cooking and baking should be made a very common practise. The present-day agitation to

bring about a more general employment of skim milk in the home should receive universal approbation, from the standpoint of both health and economy.

Many persons have little or no tolerance for sweet milk, while sour or buttermilk is well borne. For such individuals the sour milk obtained by the use of *Bulgaricus bacillus* tablets or powders will often be found to be a good substitute for sweet milk. These bacillus tablets or powders may be purchased at any reputable drug store, being prepared by a number of large manufacturing houses in this country. Skim milk or milk from which part of the cream has been removed is heated until it boils. It is then allowed to cool to about 105° F., and inoculated with a sufficient amount of the *Bulgaricus* preparation (two or three ordinary tablets for each quart of milk). The tablets or powders should be mashed and mixed with a small portion of the milk before all of the latter is treated. After thorough agitation the milk is kept in a moderately warm place (on the back of the range or in a special incubator or fireless cooker). Four to five hours at 105° F. are usually sufficient for the necessary souring, and great care should be taken to prevent the milk from becoming too acid. When the incubation is completed the product should be placed in the refrigerator and constantly kept at a low temperature, to preserve the correct flavor. For preparing a new product from day to day some of the preceding fermented milk may be used instead of the commercial preparation.

A dish that is highly relished in parts of Europe is a bowl or crock of naturally soured milk from which the cream has been removed and over the surface of which broken bits of bread or toast are distributed so as to form a complete layer. This layer is usually sweetened with table sugar, and in many instances cinnamon and other spices are employed to heighten the flavor. *Bulgaricus*-soured milk is also put to a similar use by many thousands of persons who subsist in a large measure on a milk and bread diet.

In concluding this paper the writer wishes again to emphasize the nutritional value of milk as milk, irrespective of whether it is whole, skim, sweet or sour milk. On account of the highly important known food substances which are present, namely fat, sugar, casein, lactalbumin and certain inorganic salts, and of the as yet poorly understood vitamins or accessories, milk has a most stimulating influence on bodily growth and strength, and therefore is an important factor in regulating and preserving health.

Pasteurizing or boiling for a short period does not destroy the nutritional value, as numerous experiments have without doubt demonstrated, although physicians have from time to time claimed that heated milk as a diet for small children is conducive to scurvy. Where any doubt concerning this point has existed the feeding of small amounts of orange juice has been sufficient to allay fear.

Sour milk is not beneficial on account of the acid or acid-producing bacteria which it contains, but, like sweet milk, tends to encourage the development of an intestinal flora from which the putrefying bacteria are greatly reduced or absent. This property milk seems to owe to the sugar which it contains. Skim milk exerts the same influence.

FOREST GROWTH ON ABANDONED AGRICULTURAL LAND

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ALTHOUGH the process of clearing forested land for agricultural uses continues in nearly all sections of our country, another, generally less conspicuous, but almost as important, process occurs along with it—the abandonment of cultivated land and its reversion to forest. This reversion to forest, or “afforestation” as it is called, is of great interest both to the forester and to the agriculturalist. To the former because it helps to replenish the waning timber supply, and to the latter because it provides a means of utilizing lands no longer used for raising crops and grazing.

Reasons for Abandonment of Agricultural Lands.—This abandonment of agricultural lands takes place in all sections, but chiefly in relatively remote although long-settled regions, such as some parts of rural New England. There are several reasons for its abandonment, such as: (1) loss of fertility, an example of which is the abandonment of many acres in parts of New England; (2) change of economic conditions rendering further cultivation unprofitable. The classic example of this is the large cotton acreage in Virginia and the Carolinas abandoned during the Civil War. (3) Discovery that certain lands are not suited for agriculture, at least as it has been practised in the locality. Examples of this are to be found in every region which has been settled for any length of time, where isolated fields in swampy sites, or hilltops, and the like, have been neglected when it has become evident that their cultivation was not profitable. General shifts in rural population from long-settled regions in the east to the west, and to the urban districts, have frequently caused land to be abandoned that was actually good farm land, but on the whole most of the abandoned lands have been of inferior quality.

Favorable Conditions for Tree Growth Found on Abandoned Lands.—Generally speaking, conditions are very favorable for tree growth on abandoned lands. The soil, although possibly worn out from an agricultural point of view, has been refreshed during its period of cultivation in those constituents

which make it desirable for tree growth. It is well broken so that the seed can easily reach the soil itself (often a difficult thing in the natural forest) and the roots of the seedlings can easily penetrate it. Seedlings do not have to compete with the older trees for light, moisture and growing space. If the field happens to be turfed over, once the seedlings have become established, the competition of the turf is of no great moment, although it may delay the seeding up of the field considerably in the first place. Because of the lack of inflammable litter on the ground, fire seldom interferes with old field stands, as stands growing upon abandoned lands are commonly called, during their period of establishment. This fact gives such stands a great advantage over stands coming in on cut-over lands, which must frequently cope with severe fires in the slash formed by the old cuttings. The fire hazard may, however, be quite high for old field stands during the middle period of their development, because of their frequent crowding and high density.

These conditions do not favor all trees, as there are certain species which do much better to start with under the shade of other trees, and do not take kindly to the exposed conditions of open fields, but this fact has little bearing on the situation, since it merely rules those particular species out of the race for the capture of clearings. Every humid region seems to have a sufficiency of trees capable of becoming established and growing well under open field conditions.

Influence of Other Vegetation.—Abandoned agricultural lands fall into two classes: (1) Fields not covered with turf, (2) pastures. It frequently happens that when it develops that a field is no longer valuable for crops it is seeded down as a pasture and grazed for a period before its final abandonment. This delays materially the return of the forest, but it comes back in time, nevertheless. In sections where soil erosion is common and turf does not grow especially well, such as is the case in portions of the south, its entire absence may allow such action to get the upper hand and wash away rapidly the seeds and seedlings, so that final recapture is greatly retarded or altogether prevented for long periods. Sometimes, because of close proximity of seed plants or other causes, an abandoned field is quickly seeded up by worthless brush before tree seed has a chance to reach it. This may delay but does not prevent the return of forest conditions. It seems that throughout most of the eastern portion of the United States the forest rather than the grass or brush type of vegetation is the ultimate type,

and toward it all types evolve. It is entirely probable that if all the land in the eastern United States were abandoned it would eventually be clothed in forests similar to those found here when the white man came.

Types of Natural Reforestation on Abandoned Lands.—There are two types of recapture—immediate and gradual. In the first case, almost immediately a field is abandoned a young homogeneous even-aged stand springs up over the entire area. In the second the recapture is slow and may extend over many years, the resulting stand being all-aged, in which case some of the seed which goes toward stocking the area is often produced by the earlier arrivals, so that the trees do not all belong to the same generation. On very large clearings the second type must perforce prevail, since seed can not be sown naturally over sufficient area to yield at once a full stand. It sometimes happens that several bands of growth of different ages occur on a field, that farthest from its edge being the youngest. The forester describes such a stand as “even-aged in groups.” On average-sized clearings it is generally the case that fields abandoned directly from the plow are reclaimed practically at once and support therefore even-aged stands; while pastures owing to the competition of the turf are more apt to be recaptured slowly, particularly if grazing takes place upon them, and in consequence their stands are uneven aged.

Transportation of Seed.—The recapture of abandoned fields depends primarily upon the ability of tree seed to reach them in sufficient abundance. The several agencies which aid in its transportation are: (1) wind, (2) birds and animals, (3) gravity, (4) water. Wind is the most important, it being the only one capable of disturbing seed abundantly over large areas. Its action, however, is limited to seeds of light weight with some sort of a winged attachment by which it can grip them. Wind-disseminated seeds are of three classes: (1) Very light thistledown-like seeds such as those of willows and poplars, which will float on light airs and travel for many miles; (2) medium-light seeds such as those of the birches, which can be blown for long distances, but will not float on light airs; and (3) medium-heavy, generally winged, seeds, such as those of the pines, ashes, maples, tulip poplar¹ and many others, which will flutter to the ground except in the face of a considerable breeze, and even then are not apt to travel more than

¹ *Liriodendron tulipifera*. With a few exceptions scientific names of trees have been omitted, since common names are so well standardized as to make it unnecessary.

a few hundred yards in sufficient abundance to form a stand. Birds and animals generally limit their activities to the transportation of such seeds (or fruits) as are in whole or part edible (from their points of view). The fruits of the common red cedar and the black cherry are examples. The fruit is eaten by birds and the indigestible seed is deposited wherever they happen to fly. Animals such as squirrels and other rodents generally operate by taking nuts, acorns, etc., from the seed trees or the ground beneath them into the open and burying them for food stores. It is possible that certain birds, for instance the blue jay, also do this. Gravity plays its distinctive part only on sites where heavy seed roll down-hill. Water plays its part in washing seeds down-hill and covering them with earth once they have reached their resting places. The flooding of bottomlands by overflow from streams does not seem ever to leave a sufficient deposit of seed to make any impression after the water has subsided.

Trees which Succeed in the Capture of Abandoned Fields.—As has already been intimated, a species to succeed in the capture of open fields must have several characteristics, the chief of which is that it must have seed which may easily be transplanted by natural agencies, and is produced regularly and in abundance. After that it is necessary that the species be able to start in the open, and, if necessary, to compete with grassy or brushy vegetation, and to get along with comparatively little moisture. Swamp-loving species seldom succeed well on abandoned fields. The most successful old field species are also rapid growing so that they are able to forge ahead of the brush and worthless growth which often crowds in with or ahead of them. Successful slow-growing species, such as the red spruce and the red cedar, are either very tolerant, so that they are not affected by the light competition, or are early comers and succeed by being the first on the ground. A tree must also be able to grow in closed stands, which some light-seeded species like the ashes are unable to do. On pastures or in sections where stock is allowed to range species which for some reason are objectionable as food plants for the stock have an advantage, since they are less liable to be eaten off or broken down. The tulip poplar seems to be liked by cattle and is in consequence badly damaged where grazing is allowed, while thorny trees like the black locust are almost immune from their attacks, and conifers suffer far less in this way than broad-leaved species.

Difference between Old Field and Natural Forest Types.—

As a result of the requirements necessary for the success of a species in recapturing abandoned fields, it frequently happens that the stands which grow under such conditions differ radically in composition, form, rate of growth and final yield from those of the surrounding natural forest. To the non-professional eye the most striking difference is apt to be in the species. Old field trees are in many cases trees which are of subordinate importance in the original forest. In southern New England gray birch and red cedar—the leading old field species of the region—are of rare occurrence in the long-established woodland. In portions of Pennsylvania and New Jersey the scrub oak which frequently takes possession of the old fields seldom rises to the dignity of a tree in the original forest. Further south loblolly pine, a tree of naturally limited distribution in the long-leaf pine region, seeds in abundantly on abandoned fields in that section, to the almost entire exclusion of the long-leaf itself. On the other hand, there are cases where the most important tree in the forest is also the most important old field tree. Old clearings in northern New England frequently seed up to rather dense stands of red spruce, that being the dominant tree in the original forest.

Notwithstanding the occasional similarity of species, the form of the forest is generally quite distinct on old fields from that in the original forest. Virgin forests in most cases tend toward an all-aged form. While we have seen that old fields may be either many-aged or even-aged, they generally approximate the latter. In many long-settled portions of our country the original forest has long since entirely vanished, and the form which has succeeded it differs more or less from it. In southern New England a sprout forest is now the dominant form. The forest which takes possession of the abandoned fields is of necessity of seedling origin, and therefore different fundamentally from the existing form. We might go on naming ways in which old field stands differ from the original or prevailing ones. Yet from the practical viewpoint the most important feature is their rapid growth; not only individual trees, but entire stands make more rapid growth in height and volume than takes place in the natural forest. It takes from 75 to 200 years for red spruce grown in the virgin forest to become merchantable, but old field stands of the same species are frequently merchantable at 60 years. The same acceleration of growth is observable in all old field stands. However, the timber cut from such stands is seldom as high grade as that from the original forest.

Reversion of Old Field Types to Those of the Original Forest.—In every forest region there are two classes of forest types—permanent and temporary. A permanent type is one naturally adapted to the growing site and capable of maintaining itself indefinitely without change of form, and toward which all other types occupying similar sites evolve. It represents a state of equilibrium. If a permanent type is destroyed by fire, clearing or other cause, it is generally succeeded by a forest type of a different sort, but which gradually undergoes a transformation and finally can not be distinguished from the original. Such a type is known as a temporary forest type. Old field types belong to this class. The open-field conditions which favored the establishment of certain species gradually disappear as the area becomes more and more wooded, the crop of light-seeded, quick-growing trees which crowd in at first do not always find the site favorable when forest conditions are fully reestablished. When this has largely or completely taken place the less adaptable species begin to creep in—those which can not start perhaps without some sort of protection, or the heavy-seeded species, the slow-growing ones and the like. After a sufficient time they come up through the first arrivals and partly or completely crowd them out. In northern New England hardwoods, such as birch, beech and maple, creep in among the spruces, till finally about the same proportion of hard and soft woods is obtained as is found in the original forest. In southern New England the oaks and chestnut creep in underneath the gray birch and red cedar and, after the latter have reached their normal height growth, grow up through them and shade them in. Thus the prevailing mixed hardwood type succeeds to the old field type. It is thought to require almost a century from the time the field is first abandoned till it finally passes over completely to the mixed hardwood type. Similarly in parts of New Jersey and Pennsylvania the scrub-oak type changes to one of mixed hardwoods and pine. In the south the reversion of the loblolly to the long-leaf type has not been observed, but, under natural conditions, would be expected to occur in time. It has probably been prevented because lumbering and forest fires have so far swept away the long-leaf that there are not enough trees left to act as seed trees.

Commercial Value of Old Field Stands.—From the practical viewpoint of the forester and the lumberman, old field stands are generally regarded as of much or little value according to their yields of commercial timber. They have little respect for

such types as the scrub oak in Pennsylvania and New Jersey and the cedar and gray birch in southern New England. In the former case the type is an unmitigated nuisance and is of no value whatsoever. If it could be kept out, a stand of valuable trees might be secured many years sooner. The cedar and birch type is of little value save what the birch has for cordwood and the cedar for posts. While red cedar makes excellent fence posts and has other uses, its very slow growth renders it unprofitable to encourage it. On the other hand, old field stands of red spruce, white pine, loblolly and short-leaf pine frequently have a high market value.



OLD FIELD STAND OF RED CEDAR IN SOUTHERN CONNECTICUT. Age 1-20 years.
One half stocked. Seeding up still in progress.

Aside from the species, much depends upon the form and density of the stands as to their value. Stands which do not seed up thickly enough have few trees and those few of poor form, being short and limby, producing poor knotty lumber. Stands which are too thick produce long slim poles, too small in proportion to their height to make good saw-logs. Sometimes this overstocking is so great that the trees crowd each other so severely that growth almost ceases. The forester is more and more being called upon to remedy one or the other of these conditions. In the first case he recommends the planting up of the vacant spaces with trees of desirable species so as to bring the stand up to full density; in the second, the cutting of enough of the inferior trees to allow proper growing space for the others.

Important Old Field Types.—In conclusion it may be worth while to discuss briefly a few of the more important old field types found in the eastern portions of the country. Starting in the northeastern part of the United States, they are: (1) *red spruce*, (2) *white pine*, (3) *red cedar* and *gray birch*, (4) *scrub oak*, (5) *loblolly pine*, (6) *short-leaf pine*, (7) *tulip poplar* and *other hardwoods*. Some of these types also occur on cut-over lands, but generally the two classes of sites, even when occurring side by side, exhibit sufficiently different conditions to cause pronounced differences in their forest growth, and the problems of obtaining satisfactory forest regeneration on the two are generally distinct.



Photo by Prof. J. W. Tooney.

STAND OF OLD FIELD WHITE PINE IN NORTHERN CONNECTICUT. Age 30-35 years.
Trees 16 inches in diameter. 70-80 feet high.

1. *The Old Field Spruce Type.*—On hilltops in Vermont, New Hampshire, Maine and northern New York there are many abandoned fields, most of them left vacant when the owners sought more fertile lands in the west. These have been and still are seeding up to a variety of types, but the most characteristic and valuable is the old field spruce type. It is often mixed with a considerable percentage of balsam. These lands in most cases have a commercial value soon after their establishment, since it is from them that the supply of Christmas trees sold in the northeastern United States is so largely derived. At from fifty to sixty years of age they are large enough to be cut for pulp-

wood and a few years later for lumber. As yet, except for the Christmas-tree yield, this type has no great commercial value since few stands have been long enough established. Its potential value, however, is very great. Frequently these stands are so thickly stocked that a thinning is advisable at from twenty-five to thirty years.

2. *Old Field White Pine Type*.—In southwestern Maine, southeastern New Hampshire, portions of Massachusetts, Rhode Island and northern Connecticut the original forest was largely composed of white pine mixed with a small percentage of hardwoods, although since early times the amount of pine has very greatly diminished. Abandoned fields, however, generally seed up rapidly to comparatively even-aged stands of white pine, although sometimes the pitch pine wholly or partly takes its place. At forty years of age these stands, if their density is full, may yield as high as twenty thousand board feet of lumber to the acre. To-day many such stands are being harvested—the wood being used chiefly in the manufacture of box boards. It is by means of these stands that Massachusetts has been able to maintain her place as one of the leading white-pine producing states.

3. *Red Cedar and Gray Birch Type*.—This type is common in Connecticut, southern New York and portions of northern New Jersey. It is really a combination of two types. The red-cedar type, which comes up very scatteringly over abandoned pastures, and is many years in entirely reclaiming them; and the gray birch type, which often comes up very thickly in a few years after a piece of land is abandoned directly from the plow.



OLD FIELD STAND OF SHORTLEAF PINE IN NORTH CAROLINA. Trees 10 to 20 years old. 20 to 30 feet tall.



STAND OF TULYP OPULAR SEEDLING IN ON AN ABANDONED FIELD IN THE MOUNTAINS OF EASTERN KENTUCKY. Age 10-20 years. Density full.

These two types are so frequently found mixed in all gradations that they are commonly, as we have seen, treated as one. Its chief value is that it frequently captures a field before it is overrun with a tangle of briars, sumac, sweet fern and other equally worthless plants. It is likewise exceedingly difficult for the forester to handle this type so as to make it yield commercial timber at a reasonable age. One recommendation is to cut it clear and replant it to white pine or some other valuable tree. This is of course expensive, even though as an investment it may yield a good return when the plantation comes to maturity. In addition the owner generally hesitates to sacrifice an already established stand even though its final commercial value is sure to be low. Another plan is to plant up the numerous blanks which generally occur and gradually to thin out the naturally established trees in favor of the more valuable planted ones, meanwhile thinning the spots where the natural stand is too thick, so as to encourage the most desirable of the cedars, and such valuable hardwoods as have become established.

4. *The Scrub-oak Type*.—In parts of Pennsylvania and New Jersey and to a lesser degree in other portions of the eastern United States, a type of non-commercial oak springs up rapidly on abandoned fields. It is hardly worthy of the name of a forest, since it grows to a height of only six or eight feet and forms an almost impenetrable thicket, valueless from every point of view. The acorns of these scrubby oaks, chiefly *Quercus mana* and *prinoides*, are very small and are presumably

carried to the fields by birds and animals. Their habit of growth, which is spreading, causes them to take up more room than trees many times their height. In the course of time moderately tolerant and valuable conifers such as the white pine and hemlock and hardwoods such as various of the standard oaks seed in under this mass of brush and grow up through it. The scrub oak itself is quite intolerant and as the other trees grow above it it is shaded out and disappears. The process of overcoming this pernicious old field type delays the recapture by valuable species from fifty to seventy-five years.

The practise of forestry to aid nature in growing a timber-producing forest on such sites is to plant a desirable species before the scrub oak has gotten possession of the site, or to cut it off and plant it if the oak has already come in. Under planting with tolerant species might succeed, especially if clearings were made about each individual tree as it was planted. Desirable natural growth could also be encouraged by cutting the oak away from it.

5. *Old Field Loblolly Pine Type*.—The stands of loblolly pine occurring near the coast from Maryland southward are the most important commercially of any old field stands in the country. Most of them had their origin on cotton fields abandoned during the Civil War. They become merchantable in about forty years, at which time they contain an average of from two hundred and fifty to three hundred trees to the acre, averaging about ten inches in diameter and sixty feet high. The yields average perhaps eight thousand board feet to the acre. The forester can frequently assist in increasing these yields by judicious thinnings in young and middle-aged stands. The timber from this type has already to some extent taken the place of that formerly cut in the same region from the virgin long-leaf stands, which are now all but exhausted.

6. *Old Field Short-leaf Pine Type*.—The original forest of the Piedmont Plateau section of the southern states is a mixture of short-leaf pine and various hardwoods, chiefly oaks. On old fields the pine is apt to seed in rapidly to the exclusion of the hardwoods. Since relatively little land in this section has been abandoned, the commercial value of this type is not yet great. However, short-leaf is a valuable wood and the stands seem to grow rapidly so that they will some time be quite valuable, although it is not likely that sufficient land will ever revert to forest to make them an important source of timber.

7. *Old Field Tulip Poplar Type*.—Abandoned fields in the southern Appalachian Mountains frequently seed up to tulip

poplar—the yellow poplar of the lumbermen and the tulip tree of the botanist—and various other less important broad-leaved trees. Yellow poplar is a highly valuable wood of which the supply is not too great. Since the tree seems to grow with great rapidity on these abandoned fields, such stands are of high potential value, although as yet few of them have reached commercial size. The amount of land abandoned does not give promise of ever being great enough to make such stands an important source of timber.

There are, of course, other old field types, as well as great variations in the ones here described, but those mentioned are the most typical and important, and as time goes on their importance will not be lessened.

Until the final balance is struck between agricultural and forest land in this country—something that seems a long way off—there will always be a certain amount of land passing from one state to the other, and with the growing scarcity of timber the attention of foresters and lumbermen will be increasingly interested in the stands produced on abandoned lands. The forester will be interested in seeing that the proper species are reproduced on them and that they are managed so as to secure full stocking and maximum yield. He will more and more anticipate nature by planting the land to trees as soon as it ceases to be cultivated. The lumberman will turn more and more to those stands for his supply of raw material as the virgin and long-established forests are exhausted.

THE PROGRESS OF SCIENCE

SIR HENRY ROSCOE

THE recent appearance of a biographical sketch of Sir Henry Roscoe, by his former student and friend, Sir Edward Thorpe, has added much information concerning the life and work of the eminent English chemist. At the International Congress of Applied Chemistry in London in 1909, Roscoe was honorary president and Sir William Ramsay acting president. The outbreak of the war produced in these two preeminent British chemists, both of whom have since died, a striking difference of attitude toward Germany and German contributions to science.

Ramsay contributed many articles to *Nature*, in which his hostile attitude toward everything German was apparent. "The Teutonic ideal is the compulsion of the individual by an omnipresent oligarchy." As regards the individual Germans: "They are disliked as business men; their methods are not regarded as fair, or their word as trustworthy. Even in the world of science this spirit is by no means unknown. In spite of their boasted progress in what they imagine to be civilization, they have been relapsing into barbarism." The remedy, suggested by Ramsay, is that "The nation . . . must be 'bled white.'" Would the progress of science be thereby retarded? He thinks not. "The greatest advances in scientific thought have not been made by members of the German race. The restriction of the Teutons will relieve the world from a deluge of mediocrity. Much of their previous reputation has been due to Hebrews resident among them."

As Thorpe points out in his biography the attitude of Roscoe was very different. As a student of

Bunsen at Heidelberg and afterwards he contracted friendships with Magnus, Rose, Helmholtz, Kopp, Kuchhoff, Quincke and other eminent men of science. In later years he viewed with deepest concern the growth of strained relations between England and Germany. His most recent publications were attempts to lessen the breach. "It would be an outrage to civilization," he wrote, "if two countries so closely allied in blood and intellectual development should come to blows." His last days, it is said, were filled with regret that international science should be trampled down by these nations in conflict.

Returning to Thorpe's account of Roscoe's scientific work, the opinion is expressed that his name will be longest remembered as that of the man who first established a provincial school of chemistry in England. Previously the departments of chemistry had been a subordinate division of the schools of medicine, at which even such eminent scientific men as Graham, Williamson and Frankland had failed to attract great numbers of students. Under Roscoe, the chemical laboratory of the University of Manchester became famous throughout the world, and at times students from nearly all civilized lands were to be found there.

Although Roscoe devoted much of his time to his class-room, to the development of his laboratory as an institution and to other educational matters, he was a diligent and successful investigator of chemical problems. Some sixty titles dealing with research appear under his name. His most important contributions were on photochemistry, reflecting his experiences with Bunsen, and his work on vanadium.



SIR HENRY ROSCOE.

Studies of importance were also made on the constitution of aqueous solutions of acids and on perchloric acid and its compounds. Roscoe did notable service to science by making more available for general use the work of Bunsen and Kirchhoff on spectroscopy, and by the publication of texts and manuals of chemistry in form suitable for students and laymen. Roscoe's career in research practically came to an end with his election to Parliament in 1886, although to his death he was a scientific and educational leader.

Thorpe describes Roscoe as a man of uniformly charming personality, always happy, serene of mind and most affectionately regarded by students and friends. A man of great energy himself, he was a skillful teacher, with a rare capacity to get the best out of his students. As a speaker he was simple and direct.

Roscoe came from a family of legal, literary and artistic merit. His father, a judge in Liverpool, wrote a "Digest" which was, for many years, a standard treatise. His grandfather, a member of Parliament, made a definite contribution to literature by his "Lives of Lorenzo de Medici and Leo X." He also made studies on botanical subjects. On Roscoe's mother's side were forbears of literary and artistic ability.

FOOD EXHIBITION AT THE AMERICAN MUSEUM OF NATURAL HISTORY

A FOOD value and economy exhibition has recently been opened at the American Museum of Natural History in New York City. Specimen meals adapted to all classes of the community, including many varieties of foods of high dietetic value that have hitherto been little used in this country, have been displayed. Among the new features are wild rice, both in its raw and cooked state; several new varieties

of war bread; stale bread re-baked by a novel process, and an exhibit of Chinese foods.

Unutilized sea foods were shown in variety. A fillet of shark meat, by virtue of its glistening whiteness and delicate texture, invited more general use. The periwinkle and sea mussel were shown in several preparations, and seaweeds were presented in the form of salads or vegetable dishes.

Many wild or primitive foods were exhibited in attractive guises. The acorn, for example, for many years a favorite food of the Indians of California, was shown in the various stages of preparation. The Indians are accustomed to beat and stir the acorn meal in a large vessel of water, permitting the acrid tannin to dissolve, after which the fluid is poured off, the meal dried and reground. The resulting acorn flour may be converted into a palatable and nutritious food. Totopotzl, a more primitive relative of the modern flaked breakfast food, was revealed in eight different shades, the colors being determined by the character of the brightly hued corn from which it was made. Explorers in Mexico and South America who have long been acquainted with this food declare the recipe to be well worth consideration. An instructive exhibit was the section devoted to corn (maize) and corn products. The present scarcity of wheat and other grains has brought corn into deserved prominence. Chemical analysis, as well as common experience, has shown Indian corn to be a very nutritious food, being rich in fats and nitrogenous matter and excelling all other cereals in albuminoids. Mixed with rye or whole wheat flour, corn may be made into excellent although coarse bread, varieties of which are extensively used on the European front. As a breakfast cereal, corn meal is, of

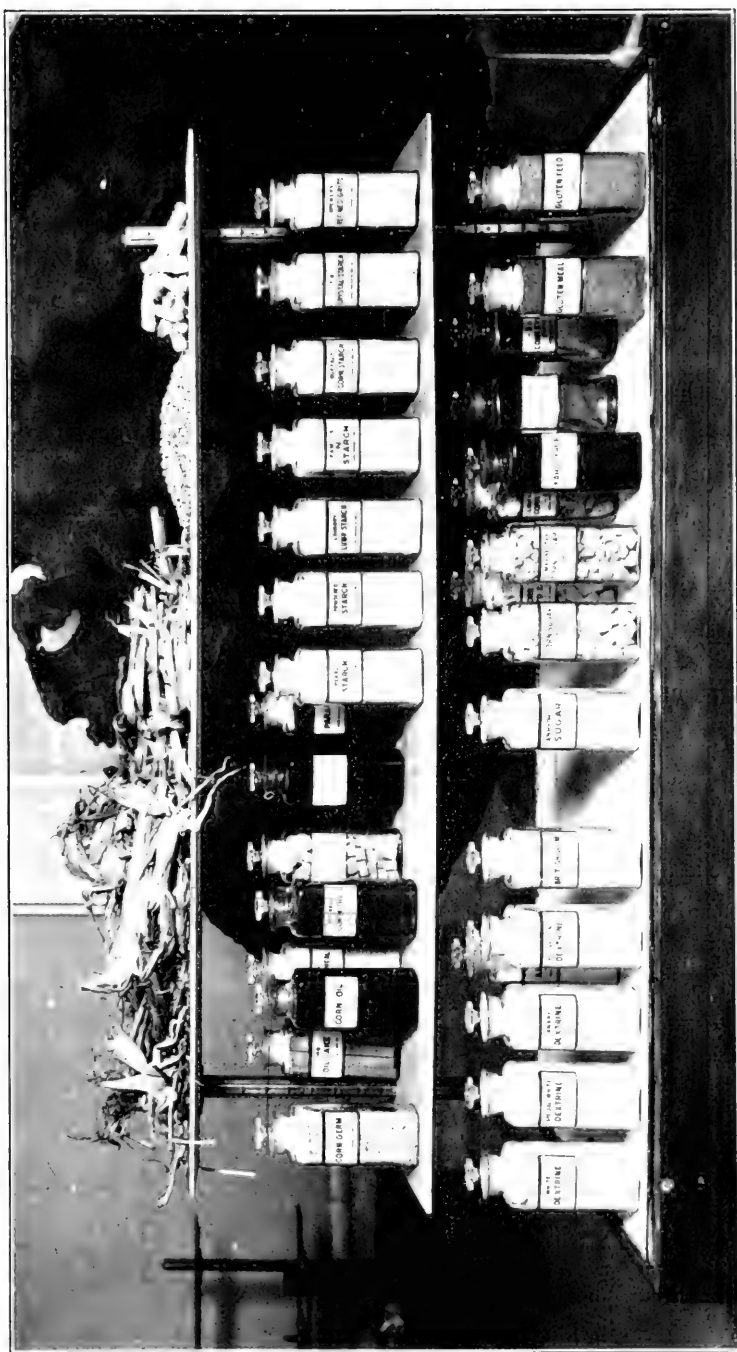


EXHIBIT OF CORN PRODUCTS AT THE AMERICAN MUSEUM OF NATURAL HISTORY.

course, well known. By depriving corn of its gluten, starch and corn starch are secured. Maize contains more culinary oil than any other cereal, ranging from 3.5 to 9.5 per cent. in the commercial grain. By distilling and by other processes, this oil is extracted for commercial purposes. Sugar, in considerable quantity, is also to be found in corn, both in the grain and in the stalks, especially of the "fodder corn," or corn sown so closely that the ears remain undeveloped. The stalks as a consequence are richer in sugar which is extracted and appears on the market in the form of sugar, syrup, and glucose. A number of other by-products of corn have commercial value, among those displayed by the museum being a substitute for rubber.

The nutritive values of other familiar foods as sold in bulk by the grocer or as served in course by the popular-priced restaurant were graphically displayed. Many varieties of dried and canned fruits, vegetables, meats and grains and such dishes as ham and eggs, corn beef and cabbage, etc., were included. Among the articles receiving special commendation were the dried prune, and pie, which is rich in nutritive value. A variety of pastry known as "Napoleon," received the highest rating of any food displayed. Other exhibits pointed to the saving to be obtained by purchasing food in bulk rather than in packages and to other economical practices.

The Public Information Committee of the museum announces that the exhibit will be open to the public for several weeks. Members of the Museum's Department of Public Health are present daily to furnish information in addition to that obtainable from the exhibits or from the comprehensive handbook.

SCIENTIFIC ITEMS

WE record with regret the death of Sir Alexander R. Binnie, the English engineer; of two French pathologists, Dr. Felix Le Dantec, professor of tropical pathology, and Dr. Louis Landouzy, known for his work on tuberculosis; of M. Joseph Riban, the French Chemist; of Dr. H. F. E. Jungersen, professor of zoology at Copenhagen, and of Dr. Juan D. Ambrosetti, director of the Ethnographic Museum at Buenos Aires.

MISS RUTH HOLDEN, recently Alice Freeman Palmer fellow in botany at Wellesley College, has died in Moscow, Russia, from typhoid fever, contracted during her work as a member of the Red Cross relief work for Polish refugees.

A STATUE of Berthelot, the great chemist, has been unveiled in the gardens of the Collège de France. He did much of his work in the laboratories of the college.

DR. ARTHUR DEAN BEVAN, of Chicago, was elected president of the American Medical Association at the meeting held in New York City in June.

DR. E. W. MORLEY has been awarded the Willard Gibbs medal by the Chicago Section of the American Chemical Society.—In honor of Dr. J. J. Stevenson, emeritus professor of geology in New York University, the faculty club house will be known as Stevenson Hall.

AN Anglo-French Scientific Commission which includes Professor Ernest Rutherford, of the University of Manchester, and Professor Henri Abraham, of the University of Paris, is at present in this country to cooperate with American men of science in the development and use of radio-telegraphy.

THE SCIENTIFIC MONTHLY

AUGUST, 1917

THE DEVELOPMENT OF MUSEUMS AND THEIR RELATION TO EDUCATION

By HARLAN I. SMITH

GEOLOGICAL SURVEY, OTTAWA, CANADA

MANY of our people have been like the little girl, who on glancing around a museum said, "Mother, Why! this is a dead circus." They do not appreciate the real use and value of a museum. We do not wonder at it when we see the dusty, uninteresting, poorly arranged collections in many museums where there are few, if any, labels and the whole tends to disgust, in fact to exemplify disorder rather than to be pleasing, helpful or educational. People think these are fair samples of museums and so such museums tend to prevent our people from knowing how useful a museum may be and from wanting any museum.

Museums are warehouses of specimens. The specimens are stored, exhibited, or both stored and exhibited. The storing of specimens saves them for future students, and sometimes from total loss. The totem poles, for instance, may be burned or neglected by the Indians with change in their beliefs and mode of life, unless stored in museums. Some museums have phonographic archives containing large numbers of records of songs of various native tribes that are becoming extinct. No one has a moral right to horde in his home a specimen which is a key to knowledge that would be lost were thieves to break in his house or fire destroy it. Such specimens should be stored where they are available to all.

Museums are something more than warehouses, however. They are certainly, if slowly, evolving from warehouse collections of specimens used only by scientists, or of mere curios for the public gaze, to peerage with research institutions, schools, and libraries. Museums employ the methods of such institutions and they in turn all use museum methods. Museums



EXPEDITIONS ARE SENT OUT BY SCIENTIFIC MUSEUMS. Pack horse with Geological Survey, Canada.

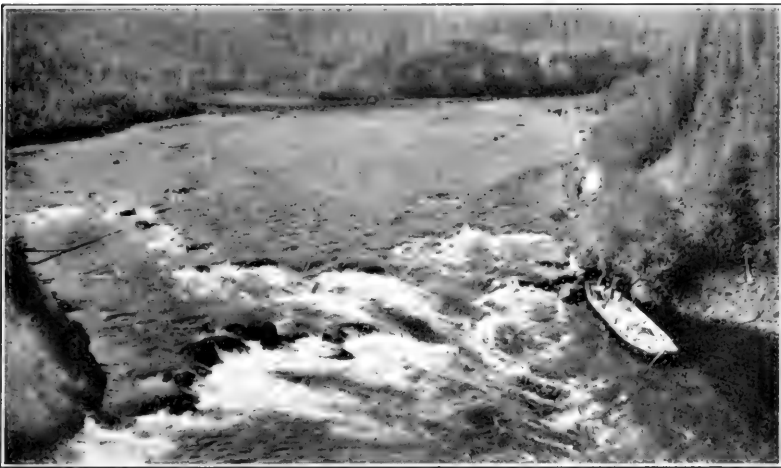


EXPLORING EXPEDITIONS SOMETIMES USE PACK DOGS.

carry on researches, teach and have libraries. Research institutions, schools and libraries, all have museums.

The great museums are making admission free and are supported, as are schools and libraries, by taxes from all, or by gifts from successful business men who realize their value.

Dime museums are being forgotten. Collections of abnormal and ugly two-headed calves and three-legged chickens are of less interest and use than undeformed thoroughbreds which are of use and beauty. People have learned that truth is more wonderful and of more social service than charlatanism, and that truth welcomes investigation.

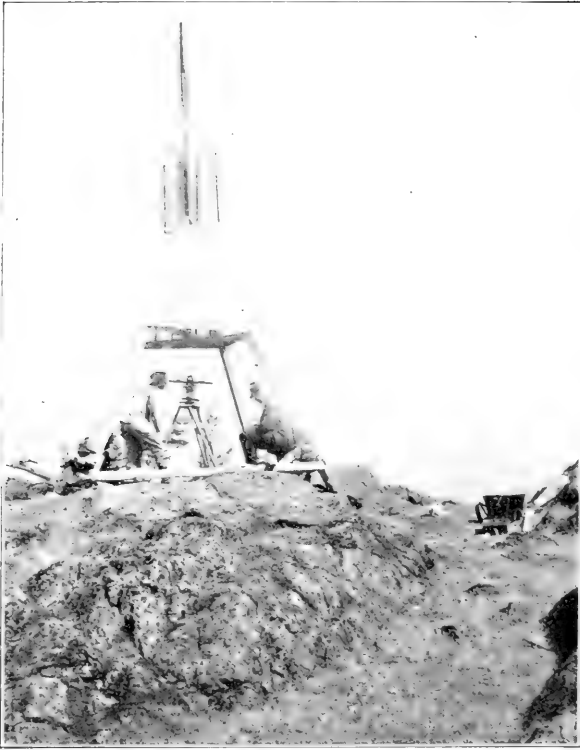


UNKNOWN RIVERS ARE EXPLORED BY SCIENTIFIC EXPEDITIONS.

THE MAIN FUNCTIONS OF ALL MUSEUMS

All knowledge is the result of research, so that research is one of the most important services to education that a museum can accomplish. The little child is a true scientist. By tasting everything he learns what is poison; by feeling fire he learns that it burns. After knowledge is thus obtained by investigation, it may be taught to all by such means as scientific reports, exhibits, lectures, encyclopedia text-books, popular guide books, magazines and newspapers, either in or out of schools, libraries and museums. No one knows who discovered how to make fire, but we learn how rather than discover how. So the older child in school loses much of his scientific method and depends more on memorizing the discoveries of others.

The research of the past produced the knowledge we learn and use to-day, but research is still going on. So all museum teaching work is based upon research. Some museums are



SCIENTIFIC WORK IS DONE IN DISTANT PLACES BY SCIENTISTS SENT OUT BY SCIENTIFIC MUSEUMS.

limited to research work and in museums recreation may be derived from seeing and learning of natural and beautiful objects.

MANY KINDS OF MUSEUMS

We have possibilities of many kinds of museums, such as scientific or research museums, university museums, school museums, children's museums, kindergarten museums, public museums, recreation, tourist or vacation museums, farmers' museums, commercial museums, museums of safety devices, museums for the blind, and art museums, while zoological and botanical gardens are kindred institutions—living or out-of-door museums. We have museums dealing with specimens from the whole world, others able only to deal well with specimens from one country, province, county or local area. Also there are national museums supported by nations, museums supported by provinces, cities and societies.

SCIENTIFIC OR RESEARCH MUSEUMS

Museums devoted solely to scientific work send out exploring expeditions, store specimens to be used for research, carry on scientific investigations, and publish the results. To get some scientific material by means of which new knowledge is found out and by means of which this knowledge is diffused to all the world, hardy men must penetrate into the uttermost wilds of the earth, endure the bitter cold of the Arctic and the dangers of the tropical forest. In the past some scientific museums degenerated into dusty garbage heaps, and research work was neglected in a stampede for "popularization" which was not even interpretation.

UNIVERSITY MUSEUMS

University museums give opportunity for professors and students to do scientific research work and supply labeled specimens, casts, models and maps to illustrate the courses of study, just as the university library supplies literature.

SCHOOL MUSEUMS

School museums not only teach by exhibiting labeled specimens that illustrate the subjects in the text-books, such as lava mentioned in the geography, and cotton bolls mentioned in botany; but they also give each student a chance to do research work, or to observe, draw conclusions and think for himself, rather than merely to memorize what his teacher tells him or what is in some text-book. Thus early in life he may have actual practise and become proficient in what he needs to do all through life.

CHILDREN'S MUSEUMS

Children's museums are similar to school museums, but are not so intimately connected with school studies and are of more general interest. They usually maintain many lecture courses illustrated with beautiful lantern pictures. Museums have so interested children in this method of study that they have to exclude children during school hours to keep them from running away from school.

KINDERGARTEN MUSEUMS

Kindergarten museums are, as might be supposed, children's museums of very elementary character. Some other museums provide a trained kindergartner to assist children in



SCIENTIFIC MUSEUMS STORE SPECIMENS TO BE USED FOR RESEARCH.
Herbarium in the Geological Survey Museum.

studying specimens. Others have so many children visitors as to require a staff of kindergartners.

PUBLIC MUSEUMS

Public museums, as the name indicates, are of material so arranged as to interest the general public rather than the scientist or the school child. They aim to provide recreation. It is now understood that education does not cease at graduation, but continues throughout life, and so exhibits of an educational character are provided that are of broad, world-wide, general interest to adults as well as to children and scientists. In other words, they are like school museums adapted to older people. Then, too, it is known that to learn of beautiful and interesting things outside of the day's work is recreation, and, conversely, that recreation may attract the people to exhibits and that, once attracted, they may be taught much that will be useful to them.

RECREATION, TOURIST OR VACATION MUSEUMS

Recreation or tourist museums aim to give recreation and to rest tired minds by directing attention in new channels and are

usually devoted to the area where they are located as supplementary to the out-door tourist attractions.

FARMERS' MUSEUMS

Farmers' museums are not yet well evolved. Possibly they will use specimens of various kinds of soil, with labels telling what crops will grow best therein. They may need samples of seeds. I have known of a farmer disgusted with his crop of seed because he had never before seen just that kind of seed in its hull and thought it was shrivelled when in reality it was excellent. Farmers' museums will probably have specimens of the eggs, the young in various stages and the adults of the chief insects which do damage to crops and with specimens showing the damage which they do to crops, together with labels telling how to get rid of such pests. The labels may tell the great total money value of the annual loss to the crops. If the museum can not afford specimens of each breed, sex and age of cattle, horses, sheep, poultry and the like, it may at least have good pictures with labels indicating the points of excellence to be arrived at in breeding. There may also be exhibits of the bones of the domestic animals with perhaps pictures of diseased conditions, and labels telling how to cure them.



VAST NUMBERS OF PUBLICATIONS ARE ISSUED BY SCIENTIFIC MUSEUMS. The Geological Survey Museum, Canada, sends a copy of each publication to every Canadian library and newspaper and to many Canadians. It also sends to many institutions and persons in other countries, and still has a reserve stock for future use.

COMMERCIAL MUSEUMS

Commercial museums show resources, industries and commercial products and are chiefly maintained by and for business men. In one, for instance, are shown boats, nets and the whole salmon industry, from the salmon to the can, or coal, with models of mines and pictures, so that if a coal man's visiting friend had insufficient time to visit the mine, he could get a good idea of it in town. Such museums appeal to business men chiefly because they advertise their wares.



SCIENTIFIC RESEARCH IS CARRIED ON IN SCIENTIFIC MUSEUMS.

ART MUSEUMS

Art museums of the past all too frequently exhibited a few old masters and broken sculptures, while the art curator sat like an owl clothed in unapproachable dignity. Now the best of them encourage beautiful handicrafts among the humbler workers, and take an interest in beautifying the place where they are located, as by advising on town planning, on the archi-

ture of public buildings and bridges, on the laying-out of public and private gardens, on the mural decoration of such places as schools and theaters and on the artistic furnishing of houses. The great artists who painted the old masters and modelled the now highly prized though broken sculptures of antiquity no doubt also did much more to beautify their cities and assist their citizens to live beautiful lives than is indicated by the broken bits of statuary dug up and shown in museums. They probably had fine gardens themselves and worked for civic improvement in all esthetic lines.

A NATIONAL MUSEUM

A national museum might include several kinds of museums or all kinds; certainly it is better able to do scientific work, special work, and cover vast areas than museums which have less financial backing and which are unable to send expeditions to far countries or to employ highly paid specialists. A national museum may present samples of all kinds of museums as patterns to the other museums of the country. A city wishing to establish a children's museum, for instance, may first study the children's museum hall in a national museum.

Aimless museums are evolving into institutions of definite and useful purposes. It is now known that each should do the work it was founded to do and is supported to accomplish, that a scientific museum is out of place in a town that is not a scientific center, a university museum is appropriate only in a university, a commercial museum is wasted except in a great mart, and a farmers' museum is not the most suitable kind for the city slum. An up-to-date museum in a small town with insufficient funds no longer tries to do what the British Museum in a large town financed by a nation does. A real scientific museum is no longer a hodge podge of a kindergarten museum and a commercial museum. A university museum now plans to differ from a museum solely devoted to scientific research and from a school museum. A museum for the general public is now known to serve the people poorly if it is labeled like a scientific museum, so that its labels do not interpret science—that is truth—to the general public in the language of the public. A farmers' museum probably has insufficient funds to devote energy to anything except the farmers' interests.

MUSEUM BUILDINGS

Museum buildings were built as architectural triumphs, but now more attention is given to building them so they will serve



MUSEUM KINDERGARTEN AND CHILDREN IN THE AMERICAN MUSEUM OF NATURAL HISTORY.

museum purposes. Some museums no longer wait for a fire-proof or permanent or larger building, as that is certainly a waste of time. I once knew of a professor who complained that he could not teach a number of interested students because he had no class room, but I believe I can recall hearing of certain great teachers of antiquity, who taught their disciples by the roadside, without either class room or place to lay their heads, and this idea also applies to museums, for, after all, the whole outdoors is the best museum. A corner in every school-house may be a museum; a nook in every board-of-trade building may serve the same purpose. Much may be learned in a cheap inflammable building, and so in it may be made a more useful museum than are some poorly managed museums possessing fireproof structures costing thousands of dollars.

SOURCES OF MUSEUM MATERIAL

The inexpensive bee from home may be as interesting and useful or more interesting and more useful than the expensive orang-outang from afar. There is enough material near a museum for all the collections it has room to house. The fish and shell fish of the river, the frogs of its banks, the insects and plants of the door yard, the birds in the trees, the animals near by, the minerals, rocks and fossils of the hills, all offer useful material for research, education and recreation. Few people can answer the simplest questions about these things and more such specimens can be collected in an hour than can be labeled with encyclopedic labels in a year, to say nothing of properly preparing and preserving them. Some museums have many friends; for instance, for years the Barnum and Bailey Circus had all its rare animals which died on the road preserved and sent to a museum.

EXHIBITS

A hall of museum exhibits is often like a great book, an encyclopedia, where each description is illustrated with a real object. A library has books containing descriptions sometimes illustrated with pictures, maybe even colored pictures, but a museum has the actual object to illustrate its descriptive label. In the early stages of museum evolution, birds and animals were stuffed for exhibition and often the animals looked like bags with four legs. Now such exhibits are made by artists. Instead of stuffing a skin a sculptor models the form of the animal as if it were alive, but with its skin removed. Then



A RECREATION AND TOURIST OR VACATION MUSEUM. The Rocky Mountains Park Museum at Banff, in the Canadian Rockies.

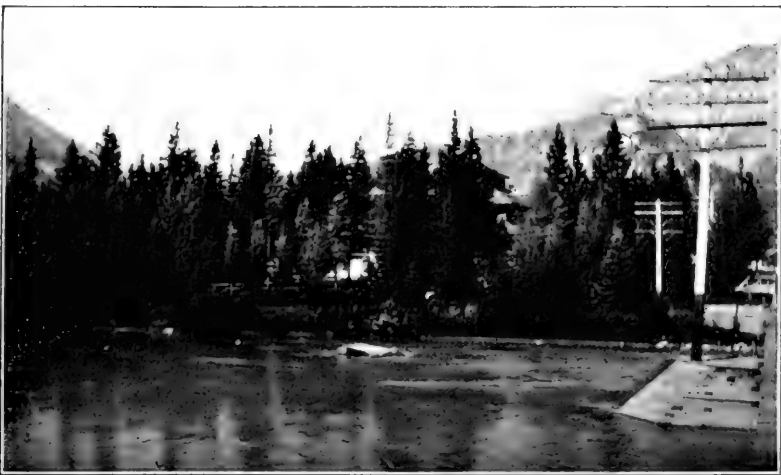
the skin is placed over this form, which brings out the real anatomy of the animal. Even exhibits to illustrate man are made in a similar way. Plaster casts are made of various native tribes. These are posed as engaged in the typical activities, colored to resemble the living people, dressed in the proper costumes, and placed among the natural surroundings in front of a painting made by an expert artist, to illustrate the home country. This work can not be done by untrained men, but must be accomplished by artisans, mechanics and artists who have had very special training each in his own particular line. Sometimes in a country of millions of inhabitants there is no man trained in a certain special kind of work, so that a museum often has to send across the sea or to some equally far-away place for a skilled mechanic. Even Japanese, Eskimos and Indians are employed in one of our largest museums.

Some exhibits are made especially to be pedagogic, as, for instance, to show the life of a moth from egg to adult. Such exhibits are visited by school teachers with their classes.

Sometimes models teach quite as much as actual specimens. A model of a mosquito made many times larger than the insect itself shows us how to cope with malarial fever and yellow fever. We could not see the means by which the mosquito transmitted these diseases by looking at the mosquito herself,

but the scientist in his laboratory with his microscope may find out all these things, make accurate plans and drawings of the various parts of the insect, and leave it to skilled mechanics to spend many months in reproducing them accurately on a large scale. Such work is not an extravagance when we consider that if the doctors and the people learn to avoid yellow fever and malaria the life-insurance companies do not have to pay so much life insurance and the amount paid for one death is easily sufficient for the construction of such a model.

Pictures are very useful with exhibits. For instance, bones of extinct animals are frequently found. No one knows what these animals looked like in life, but the scientist can study the bones and compare them with the bones of animals which he is able to observe. His artist can paint these living animals and he can explain to him in what respect the bones of the extinct animal differ. By a study of the bones of the feet he may learn and explain to the artist whether the animal walked in a swamp or on rocky ground. By a study of the animal's teeth he may tell what kind of food it ate. Then the artist can make his picture very much more intelligently than otherwise would be the case, and this picture conveys to the people some idea of what the animal formerly looked like. Sometimes the artist makes a sculpture of the animal instead of a painting or to accompany the painting, so that a complete exhibit might show a skeleton with a painting, a model, a label, a map, and perhaps even another animal, such as lives to-day and is akin to the extinct animal.



FROM RIVER BOTTOM TO MOUNTAIN TOP NEAR THE ROCKY MOUNTAINS PARK MUSEUM IN THE CANADIAN ROCKIES ENOUGH SPECIMENS MAY BE COLLECTED TO FILL THE ENTIRE MUSEUM.



INEXPENSIVE TREE EXHIBIT, made as a by product of less than a day's work.
Rocky Mountains Park Museum.

Specimens are arranged together for such purposes as to illustrate the idea of evolution, to show all the different musical instruments of the world, or to show all the things found in a certain province or all the animals, plants, minerals, and so forth, of a certain region, as, for instance, a desert, and contrast them with things from a forest.

Scientific books, that have been based on specimens and illustrated by pictures of the specimens, are often placed near the exhibits of the specimens, as are also guide books, especially written for the public, that is, giving the main scientific facts translated into the language of the people, but omitting details of interest only to the scientist or as matters of record.

Some museums make a special effort to prepare timely and useful exhibits and place them most conspicuously. These are sometimes hastily made to meet an impending demand for knowledge. In 1912 the tent caterpillars were so numerous in the vicinity of Ottawa that they destroyed the leaves of many shade and ornamental trees in the city and many fruit trees

on the farms, as well as forest trees. They were even so numerous that their presence on the tracks delayed railroad trains many hours. The number of eggs on the trees in the spring of 1913 showed that this damage would be repeated, so an exhibit was prepared for the benefit of the people. One side of the case shows the life history of the tent caterpillar and some of the trees which it attacks. On the opposite side of the case are shown some of the means of controlling this pest. There are birds, photographs, lumps of chemicals, and a pail of commercial tanglefoot—an exhibit of inexpensive things that may save a city's shade trees—as useful an exhibit as one of rare objects. Magnifying glasses are used as an adjunct to this exhibit so that some of the smaller specimens may be more easily seen. When pressing need for such an exhibit is past, it may be retired or put in a less conspicuous place. This is an example of how officers of museums are endeavoring to find out what is useful to the people and to prepare helpful exhibits.



BUFFALO SPECIMENS GROUPED BY LOCAL LABOR AND CASE BUILT BY LOCAL CARPENTER IN ROCKY MOUNTAINS PARK MUSEUM. Such a case can be made for ten dollars wherever window sashes are available.



CASE WITH SASH REMOVED IN ROCKY MOUNTAINS PARK MUSEUM. Such a case can be made wherever window sash can be had. This ten dollar case is as useful for teaching purposes as five or six hundred dollar cases of some museums.

EXAMPLE OF USE OF STAFF

Officers of a museum have sometimes served the public on commissions or in other ways outside of the institution. For example, one zoologist was a member of the international commission which arbitrated the seal question.

LABELS

A museum of specimens of things of which we should

EXAMPLE OF USE OF EXHIBITS

An example of the use of a museum exhibit is illustrated by a page of designs taken from an exhibit of Indian handiwork. This page was distributed by an art teacher among all his students in the public schools in his work to better the designs of furniture, wall paper, stoves, etc.



POLICE AND FIRE PROTECTION IS GIVEN SPECIMENS IN MUSEUMS. Museum of the Geological Survey, Canada.

know, rather than of things merely curious or from so far that they do not affect us, if labeled and accompanied with models, maps and pictures, may easily be of more social service than some existing museum costing say ten times as much. In order to give this information clearly large classifying signs, smaller signs and still smaller descriptive labels are used and are as important as specimens. Besides these there are labels for each specimen chiefly to tell where that particular specimen is from and what it is. A collection of labels without any specimens might be of more service in a museum than a collection of specimens without labels. Labels asking questions may be used in a school museum to cause the visitor to observe closely and find out things for himself.

Publications are issued by various kinds of museums for as many purposes as the museums serve, such as records of research, complete catalogues giving details, popular guides calling attention briefly to the chief things of interest, and journals to interest people in museum work. Guide-books sometimes illustrate more than half the specimens exhibited, so the visitor from a thousand miles away may carry to his friends at home a glimpse of a large part of the exhibit with a full description and even with reference to authorities, for their use in case they care to pursue the subject into original sources. Some museums give such guide-books to the public, but as certain classes of people throw them away or destroy them, other museums prefer to charge a small sum for guides. This charge is usually less than the cost of the book.

Many museums now invite the people, through the public press, to avail themselves of its advantages. Often people would not know what they are missing, as of recently acquired material, and scientific news, were these not advertised in the papers. Business has found advertising to pay and museums now appreciate that it does. The citizens pay the taxes which make the scientific work of some museums possible and the staff feel in honor bound to lay aside their research for a time in order to explain in non-technical language such results of their study as may be valuable or merely interesting to the public.

Publishers are encouraged to make postcards of museum exhibits and in this way through the natural channels of trade information is spread far and wide without any expense to the museum.

LIBRARY

Libraries constitute part of the equipment of many museums and suggest a tie between museums and other educational insti-

tutions. The books are used by both staff and visitor. The staff always needs to inform itself in order to do its work of research, preparing, installing and labeling.

VISITORS

Different classes of visitors use museums, rich and poor, wise and ignorant. Carpenters often study the specimens of woods, miners the minerals, teachers of art and architecture the collections of primitive art and the objects and pictures, showing the types of building of other times and other peoples.



PAINTING BACKGROUND FOR THE LOBSTER GROUP IN THE GEOLOGICAL SURVEY MUSEUM, CANADA.

This work can be done by untrained men.

Normal school classes that study in museums scatter what they learn from the exhibits to school children as far and wide as the region their normal school represents.

On the occasion of an exhibit for the prevention and cure of tuberculosis in one museum, over forty thousand visitors passed between the police lines in and out of the exhibit in a single day, which proves conclusively that the public is thoroughly alive to the importance and value of the most modern and useful museum work.

LECTURES AND PHOTOGRAPHS

Lecture halls are included in the equipment of many modern museums. One museum has three lecture halls and gives lectures every day. Each lecture is made as appropriate to the audience as possible. So there are simple lectures for children, general lectures for the public, and specialized lectures for scientists, or people interested in the details of a single subject. There are also lectures for teachers, and for those who wish general entertainment in the lines of museum work. Even short informal talks, sometimes illustrated by specimens, are given when desired in exhibition halls, offices and shops.

The lectures are usually illustrated with specimens or lantern views, in some cases thrown up over thirty feet square and unsurpassed in coloring. Even the moving picture is used. Some museums collect vast numbers of negatives, some of them taken on expeditions, which form a great historic archive of increasing value as time passes. Prints are used for illustrating scientific papers, encyclopedias, text-books, popular books, magazines, newspapers, and the like, and from them are made hundreds of sets of lantern slides for illustrating as many lectures. One made over seventy duplicate sets of slides of each lecture, and sent them throughout a whole state for the use of all the teachers. It specified that no admission should be charged. Large audiences attend museum lectures. Seven thousand children once tried to hear a single lecture in a museum hall holding only 1,400, but eleven extra lecturers were called by 'phone from the door, the children were deflected to twelve different halls and were interested and instructed.

The photographs made from negatives taken on expeditions are kept in files or in scrap-books where they may be consulted, and prints are given out in small numbers free of cost, or in large quantities for the actual cost of the photographs, without regard to the expense of the expedition necessary to secure them. These are given to scientists for study and for illustrating their books, to educators to use as illustrations and to hold up before their classes. Many of them are used by magazine writers and newspaper men for illustrations and by sculptors and painters. In this way the explorer brings back glimpses of far-away lands which eventually are shared with people unable to travel or who must travel nearer home.

LOAN EXHIBITS AND MEETING PLACES

Some museums loan space for special and temporary exhibits such as art loans, flower shows, and sanitary exhibits,



SPECIMENS ARE NOW MOUNTED ACCORDING TO A MODEL JUST AS A HOUSE IS BUILT ACCORDING TO AN ARCHITECT'S PLANS AND SPECIFICATIONS.
Geological Survey Museum, Canada.

of which one illustrated the fight against the great white plague. For a few hours or days such exhibits are placed in front of the permanent museum exhibits.

Museums also become social centers or headquarters for scientific and educational purposes, where any or all classes of people may learn of or enjoy such things as art and science. The large lecture halls are particularly appropriate for general meetings and the smaller rooms for special societies.

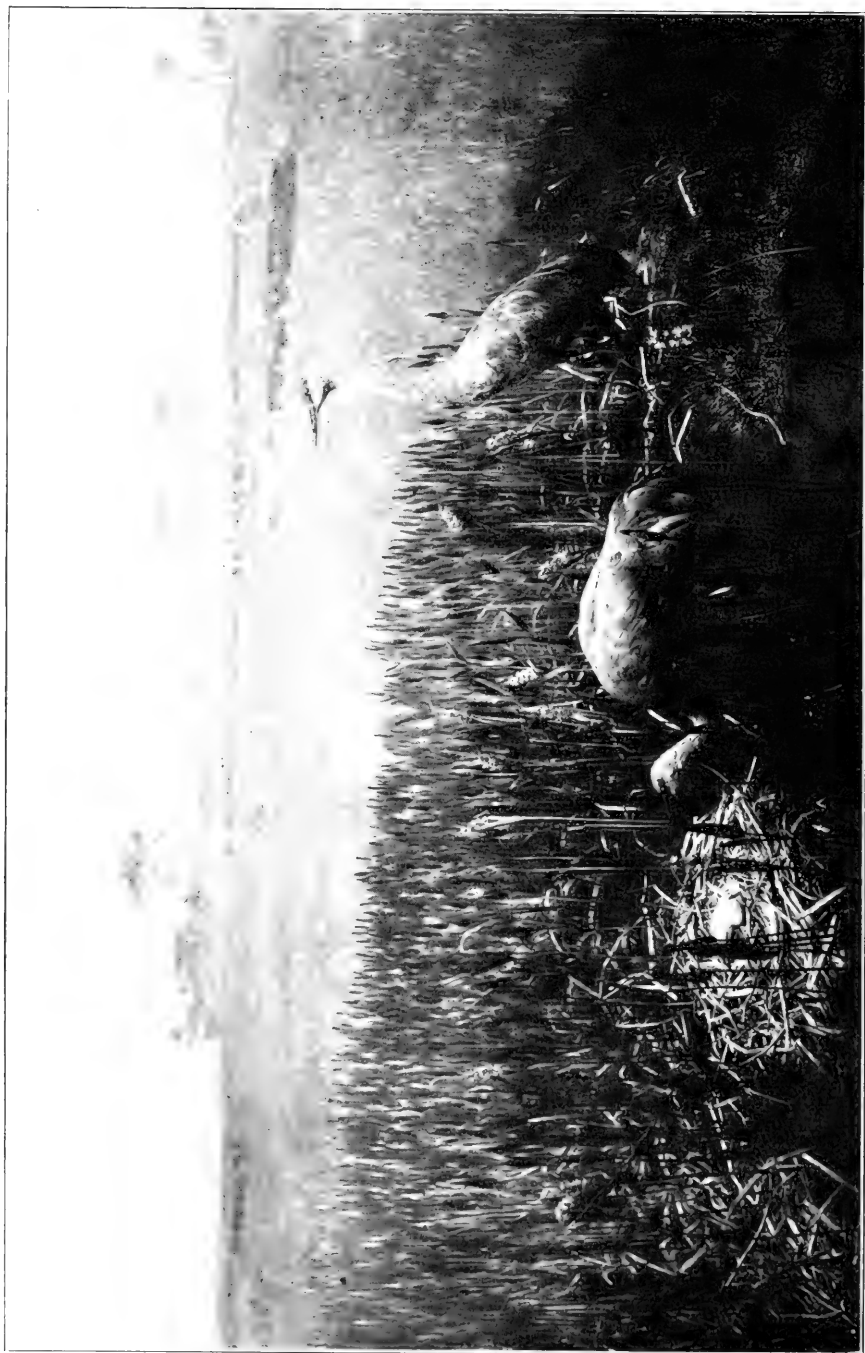
TRAVELING EXHIBITS

Where a few specimens are needed by thousands it is easier to move the specimens than the people. Branch banks, university extension lectures and traveling libraries grew out of a similar cause. Exhibits are put up in carrying cases with labels and guide-books describing the specimens, and these are sent from school to school, to libraries and other suitable places. In St. Louis, Chicago and New York, for instance, the success of this work has necessitated the use of museum automobile delivery vans and many thousands of children are served.

The business men of Canada for several years sent a train known as the "Made in Canada Special" throughout the length and breadth of the country. This train contained exhibits of the manufactures of the Dominion. It was a commercial museum on wheels, and it stopped only a few hours in the places visited, but it was thronged with visitors anxious to learn of the manufactured products of the country. Agricultural colleges and railroads have been using a somewhat similar method to uplift the people, and, if business men find it worth their while to educate the citizens, it would seem to be the duty of educators to consider this method for museum extension. Useful exhibits and moving-picture lectures installed on railroad cars side-tracked at various places would not only carry art, science and other phases of social service to places where no museum exists, but also present a model of methods to museums.

MUSEUM COOPERATION

There are over sixty museums in Canada, counting large and small. They are found from coast to coast, but are most numerous in the older settled and most cultured parts. Specimens are often loaned or given to smaller museums by the larger ones. Encyclopedic labels may be more economically produced if written by one curator, criticized by several, and printed for all. This saves the expensive duplication of writ-



SAND HILL CRANE GROPP WITH HOME SURROUNDINGS AND PAINTED BACKGROUND IN AMERICAN MUSEUM OF NATURAL HISTORY.

ing and typesetting and has the advantage that the labels are more accurate than if the work of one man working without criticism. Some such labels have been prepared by the Dominion government and offered free of charge to all the museums of the Dominion. At least eighteen museums and one zoological garden have taken advantage of this cooperation. A national museum may thus become a clearing house for all the museums of a country.

CONCLUSION

A finished museum would be a dead museum, but there is no such thing as a finished museum, for scientists are always making new discoveries which lead them to add new things, and to rearrange or re-label old material.

The museum that really teaches the children of to-day, and otherwise becomes useful to the public with clean though cheap cases, will gain the sound financial support which it deserves, at least as soon as the children of the present generation grow to positions of authority. The museums certainly have a great opportunity to be open on Sunday and at hours when those who work and all those who wish can make use of them. They may cheer, educate and uplift the humbler workers and the slum dwellers. These are the people, who, unable to travel, or perhaps even to buy books and pictures, may need the services of museums and kindred institutions more than those who have wealth and leisure or any other class. Museums may compete with ignorance and vice by pointing the way to the appreciation or use of things now neglected or unknown, and to greater joys and healthfulness through beauty and knowledge, until there is no room left in the mind for vice. Schools and universities had to struggle for recognition. Only a few years ago some communities looked upon libraries as of little or no importance, but now prize them highly. Museums come next in this evolution. Museum men may not know yet just how to perfect museum work, but if all carry on experiments and evolve useful methods as rapidly as some have during the past twenty years we may expect that within the next twenty years we shall have some museums at least that will be considered as useful as our best schools and libraries.

MINERAL RESOURCES IN WAR AND THEIR BEARING ON PREPAREDNESS

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I

THE raw materials of war are men and minerals. The one stands in immediate contact with the enemy; the other lies back of the organization that supplies the munitions of war. The first has always been recognized as of prime importance; the second has been forced into prominence only by the unprecedented conditions of the European contest. But even now attention is too exclusively focused on the *industrial* aspects of the problem of preparedness, and too little care has been devoted to the ultimate sources of the materials of war, to a study of mineral resources from a military standpoint.

War has changed from an art to a science. It has come to be a large-scale engineering operation—a conflict of vast quantities of materials, handled by skilled labor, directed by expert knowledge. It is now a matter fundamentally of applied physics, chemistry and geology.

A result of the development of war along material lines has been the tendency to reduce the men on the battlefield to a dead level of equality. The bravest or the most numerous army no longer wins; the victor is the army best equipped, the one with the best home organization back of it—ultimately the troops of the country that commands the largest supply of coal, iron and fertile soil. The present war, indeed, has been termed by various writers “a war of coal and iron,” “a war of metals,” and the like.

The manufacture of most of the munitions of war, and of actually every implement of fighting, depends upon some mineral resource. Guns, projectiles and armor plate demand iron, copper, zinc, lead, antimony, manganese, nickel, chromium, tungsten, molybdenum; not one, or several, but all. The lack of a critical steel-hardening metal, though used in small quantities only, would render the most extensive iron deposits void for military purposes. This England discovered to her discomfort at the beginning of the War; to her disaster, had com-

mand of the seas not been hers. Explosives require nitrogen, sulphur, carbon, aluminum, and certain organic products obtained from the destructive distillation of coal. The railway, the ocean vessel, the motor truck, the aircraft, all depend upon coal or oil and many metals. Without copper and platinum, the telephone and wireless would remain silent. Even the surgeon draws many of his most essential drugs from coal-tar derivatives; while food and clothing, without which all other supplies would avail nothing, are direct or indirect products of the soil, for the quickened production of which potash, phosphates and nitrates must be available in abundance.

And not only must an army be munitioned, it must also be financed; and here a complexity of factors enters, not the least of which is the activity of the mining industry in general and of the supply and output of gold in particular. The fact that at the outbreak of the European war the British Empire had long been producing about three fifths of the world's gold, while the Central Powers were contributing less than 1 per cent., introduced an economic condition whose significance would have been more apparent had circumstances been reversed and Germany, and not the Entente, been the great purchaser of supplies on the American market. The Central Powers could better afford to be without great reserves of ready gold than their enemies.

In a table of the eighty chemical elements composing the universe, I have just counted thirty that are required in modern warfare. Lacking these, or the ability to obtain them, no nation can stand by virtue of superiority in either numbers or quality of men. The want of even a single essential may prove disastrous.

Countries rich in developed resources, therefore, are much better prepared for war than those whose mineral resources are scant or imperfectly developed. In fact, no country can become a great world power without extensive and varied mineral wealth. The British Empire, the German Empire, and the United States have achieved this end; the Russian Empire, China, and a confederation of South American republics, to include at least Brazil, Chile, and Bolivia, have this possibility. Argentina is the most exclusively agricultural country in the world, yet it is certain that she could not obtain a dominant position on that alone; for such an accomplishment, alliances with neighbors rich in minerals would be essential. An embargo on coal shipments from the United States under present circumstances would seriously embarrass, if not disrupt, her economic life.

Germany could not have maintained her stand in the present war had her territory been poor in variety of minerals or had not her chemical skill risen to fill gaps in her natural products. Of essential minerals, she has probably felt a serious stringency only in copper, nickel, aluminum, tin, antimony, manganese, petroleum, and nitrogen; but her chain of strength was kept from breaking at these weaker points by accelerated metallurgical and chemical developments, the extension of mining to low-grade deposits, heavy importations at the outset from Norway and Sweden, and probably also by anticipation and storage of these very products in large quantities in advance of hostilities. Her supply of iron would have proved inadequate if the events of 1871 had not placed in her hands the great iron-ore fields of Lorraine, which more than doubled her reserves of this metal—an advantage not generally appreciated at the time, as a suitable process was then lacking for working these low-grade ores. But their significance became apparent enough in 1914 when the German line embraced the extension of these fields lying in French territory east of Verdun and the French iron industry was thereby deprived at a single stroke of over 85 per cent. of its supply of ore, which was soon diverted into German blast-furnaces. It is surely the irony of fate that Germany to-day is practically waging the war with iron drawn from territory formerly French and worked into steel by a process devised by two Englishmen!

England has abundant iron and coal, but is deficient in most other mineral products of military significance. France is a manufacturing nation with few mineral resources, and of these her most important, the coal and iron fields adjoining Belgium and the German frontier, were captured early in the War. Russia (including Siberia) is a country rich in variety and quantity of minerals, but not only are these resources for the most part undeveloped, but their very distribution and extent are imperfectly known. In consequence, Russia has more men than she can adequately arm and munition. Industrial organization for war is one problem and can be quickly arranged for—behold England; the development of a country's resources is a different matter and can not be accomplished in a brief period of years—that Russia has learned to her loss. Therefore, it has devolved upon the British navy to maintain the command of the seas, not only that England herself might be provisioned, but that her allies might be supplied with the raw materials of war which their own territories alone were unable to furnish.

Looking further, we see in China a region of vast extent with a mineral wealth almost wholly undeveloped, to a large extent unknown, yet shown by successive explorations to be of great potentialities. For this and other obvious reasons, China is unprepared for a struggle with even a third-rate power; yet she has the raw materials of a world power. It is not unreasonable to suppose that Japan, herself rapidly developing to the limit of her restricted territory and resources, is seeking new fields for expansion; she has doubtless many times had visions of what an organized China might be; certainly those who would impute to her ambition designs against the distant shores of California, forget that at her very door lies a country probably nearly as rich in a material way as America ever was. China developed, we may have Japan to reckon with; as it is, the resources of China must appeal to Nippon as more alluring than the vague idea of a Japanese state in North America.

II

Not only is war to-day directly dependent upon mineral resources, but the development of the art of war through the ages has followed rather closely the advancing exploitation of mineral deposits. Stages in the upward progress of primitive man indeed are actually marked by the implements used by him in the chase and in war, according as these were of rough stone, of polished stone, of bronze or of iron. Lucretius, the Roman poet, recognized this fact two thousand years ago when he wrote:

Weapons of old were hands, nails, and teeth, and stones, and boughs broken off trees, and flaming fire, as soon as it had become known. Afterwards the use of iron and copper was discovered, but the use of copper was earlier than that of iron; for it is easier to work and is found in greater quantity.

The accounts of the earliest wars bristle with spears, javelins, helmets, arrows, and catapults—all products, in part at least, of mines and quarries. The stirring lines of Homer resound with the clash of arms, and every school-boy knows the trappings and implements used by Cæsar in pressing his Gallic Wars. Ancient warfare was dependent upon stone, iron, bronze (copper and tin), and oil.

The two greatest inventions of the Middle Ages were printing and gunpowder. But the printing press is not our theme, however much it is dependent on lead and antimony or is now gorging itself on the details of modern fighting. When a German monk by the name of Schwartz (although there are some

who would claim the honor for Roger Bacon) ground up a mixture of charcoal, sulphur and saltpeter, in the seclusion of a fourteenth century cloister, he loosened a force that was destined to shake the ages. The contribution of this early Teuton militarist altered the whole course of war; seized upon by the forward sweep of western thought, the principle of violent disruption was not allowed to sink beneath the lethargy of inaction, as had happened ages before in China. Soon the arquebus replaced the spear, and Mars himself, like the American Indian a little later, must have been surprised at this new and fearful "speaking death."

It is not necessary here to trace the development of the implements of war from medieval to modern times. The very names of blunderbuss, matchlock, muzzle-loader; of battle-axe, rapier, cutlass, saber; or of pike, lance, bayonet will call up vivid pictures of successive stages; while the appliances used in recent years are too familiar to need recounting. From the sixteenth to the middle of the nineteenth century, chemical elements of principal military note were iron, lead, carbon, sulphur and nitrogen.

Of these, nitrogen was critical. The available supply of this element was limited, in spite of its abundance in the atmosphere. It could be obtained only from sporadic deposits in caves, from the surface of some soils in semi-arid regions, and from accumulations of refuse matter—all undependable in time of need. A plan was later developed for inoculating the soil with colonies of nitrifying bacteria, and for a period niter plantations were common industries in Europe, and even in this country at the time of the Civil War.

But any widespread manufacture of explosives was impossible until the discovery in 1821 that the desert of Tarapacá near the west coast of South America was underlain by a blanket of sodium nitrate gave to the world an unexampled source of the elusive constituent. The development of these nitrate fields in the most unmitigated desert in the world, against serious political and climatic obstacles, advanced the arts of peace no less than those of war and rendered possible the developments in mining and transportation that have characterized the last half-century. The total effect upon civilization of this mineral occurrence, which a single rainy season would wash away, can scarcely be estimated.

It is now clearly recognized that the Chilean deposits will not last always, nor could they be relied upon by a country in periods of effective blockade. These are facts which have stim-

ulated the development of the by-product coke oven, which yields nitrogenous compounds on the distillation of coal, and of several processes for separating nitrogen from the atmosphere and fixing it in usable form—advances that have been carried further in Germany than elsewhere, much to the advantage of that country in the present struggle.

III

As economic factors in shaping history, mineral resources have played an important rôle. In particular they have been a direct or contributing cause of many wars. The war between Peru and Chile in 1879–82 and the Boer War form two notable examples.

The Peruvian-Chilean war grew directly out of the development by Chilean interests of the nitrate fields, which extended from northern Chile across what was formerly a part of Bolivia into Peru. The conditions were ideal for trouble—a valuable mineral deposit, exploitation by foreign capital, unstable government, excitable temperaments. The result: Chile has now a monopoly on sodium nitrate, Bolivia is without seacoast, and Peru is minus her rich province of Tarapacá. The acquisition has made Chile the most prosperous country in South America, save one; her royalties from these fields sum up to hundreds of millions of dollars, and her very existence is bound up, as that of no other country, with the production of a single mineral deposit.

The Boer War was a by-product of gold mining in the Transvaal. The Rand district, discovered in the late eighties, drew the usual rush of gold-seekers, which met with disfavor on the part of the Boers. But the richest gold deposits the world has ever known had to produce, in spite of economic and political obstacles devised by Kruger and his government. The relations between the “foreigner,” which meant the mining interests, and the Boers grew more and more strained; then came the Jameson Raid in 1896 and finally British intervention in 1899. Now the Rand mines are producing over \$15,000,000 a month and aiding to finance the European struggle. Thus we have a literal illustration of the statement: “Gold the producer of War; War the consumer of Gold.”

The desire for mineral wealth has always been a powerful motive in directing discovery and settlement. The Spanish Conquest in the two Americas forms a romantic example of men lured to great deeds by the lust for gold. The hope of finding the fabled “Land of El Dorado” was a very real incen-

tive to the adventurers who followed Cortes, Pizarro and Quesada on their wild and successful expeditions. In more recent time, the California gold rush of '49, the stampede to the Australian gold fields two years later, the discovery of diamonds in South Africa in 1869, and the Yukon fever of '98 are events which opened up continents and made empires of the waste places of the earth.

The Mexican situation to-day, at bottom, is rendered an international problem by the fact that foreign capital is exploiting the mineral wealth of a country—and Mexico's mineral wealth is great—in opposition to the wishes of many of its inhabitants.

Mineral resources play a rôle, if oftentimes an unspecified one, in the diplomatic relations between nations. A nation poor in mineral wealth tends to seek alliances with powers strong in the essentials lacking. The contest of European capital in developing backward or semi-civilized regions, the rivalry thereby entailed, and the desire on all sides to gain fields for future exploitation were factors of importance in shaping circumstances that led to the present European war. And we may be sure that the international rôle of mineral resources will assume greater importance in the future, when the stress of waning mineral reserves becomes more acutely felt.

IV

The intimate relation existing between war and mineral resources is shown nowhere better than in a plot of metal prices in the United States over the past three years. Under the stimulus of abnormal demand, munition metals have soared in value beyond all precedent, and a chart of their wild careening now looks more like an involved seismograph than a sober table of accurate facts. The different metals have responded differently to the war influence, showing an individual sensitiveness to the changed conditions in Europe; but in general the effect has been an immediate though somewhat small drop in price, followed by a sharp climb, in some cases to figures many times the normal, in turn succeeded by marked oscillations, but a general maintenance of a high-level average.

Pig iron, to consider the most fundamental metal first, held close to \$15 a long ton during the first year of the war, but in July, 1915, began to climb slowly but surely until it reached a height of over \$30 by the end of 1916. Copper, whose average price for thirty years preceding the war was almost 14 cents

a pound, and during 1912-13, 16 cents, dropped a little during the first few months of hostilities, but recovering early in 1915 reached 20 cents before the year was half over and ended 1916 above 31 cents. The career of zinc was even more spectacular; long used to a price that hovered around 5½ cents per pound, it responded with a few months to war conditions (the centers of the zinc industry abroad lay in Belgium and Germany), and during the first six months of 1915 jumped from 6 cents to 21 cents, only to fall back to 15 cents by December; in 1916, it experienced a sudden set-back upon the reorganization of the European zinc industry, sinking to 8 cents during the summer months and ending the year close to 11 cents. The war caught silver at 55 cents per ounce; its price thereupon slowly went down until April, 1916, when it abruptly advanced 10 cents, going to 74 cents in May and remaining near that figure through 1916. Antimony was formerly of limited use, but the war created a large demand, and "this being precipitated in an unprepared mining industry, the price rose by leaps and bounds"; originally 8 cents a pound, this metal commanded 42 cents at the beginning of 1916, and 46 cents in March of that year, but war-inspired production in China began then to be felt and it dropped to 14 cents by December. Aluminum entered the war at 17.6 cents a pound; 1916 saw its price average 60.7 cents. Other examples might be cited, but these are sufficient to show that the prices of the common metals in a peaceful country were increased fifty to several hundred per cent. because of demands put upon them by a foreign war.

These conditions have given an unparalleled impetus to mining throughout the world, and especially in the United States. The mining industry of this country is enjoying the wildest prosperity in its history; American mining companies that publish their dividends paid \$170,000,000 in 1916, against \$78,000,000 in 1915. New mines are being developed, old mines reworked, and many deposits are now producing which could not be operated under normal conditions. The return of former prices would spell disaster for many enterprises.

The zinc industry has been affected in a peculiar and interesting manner. In 1913, of the world's supply of this metal, the United States produced one third, Germany one fourth, and Australia one fifth. Most of the foreign ores were smelted in Germany and Belgium, Australia's output from the famous Broken Hill mines going almost entirely to these two countries. Little zinc was smelted in England; the smelteries in France lay near the eastern frontier. The entire zinc industry of

Europe therefore passed into German hands; and the United States was called upon to supply the shortage of zinc among the Allies, who found themselves in the position (one which might have easily been foreseen) of having plenty of zinc ore, but no means of rendering it useful. The price of zinc soared; American zinc flourished as never before; the Australian mines faced disaster. Then the situation readjusted itself; smelters were built in England; electrothermic furnaces sprang up in Norway and Sweden; Japan, China, and Canada became producers; new markets, among them Japan, were found for the Australian ore. The price dropped; the stringency cleared up.

The Russian mineral industry felt keenly the effects of war, as it was wholly unprepared to get along without the markets of Germany and Austria, and as there were many gaps in its production which these countries had been relied upon to fill. Under the stress of circumstances, then, the Russian government did more for her mining industry in a few months than it had previously done in years: a systematic study of the mineral resources of the empire was undertaken; a corps of geological engineers was sent to carry on prospecting explorations in the Urals, the Caucasus, and Siberia; the land tax on gold fields was reduced; roads tapping mining regions were improved; and in general a lively interest was evinced in an eleventh-hour development of neglected mining opportunities.

France, deprived of her rich iron-ore fields near Verdun, was forced into quickened exploitation of lower-grade deposits in other parts of her territory; but the loss of her principal coal-fields could not be compensated and she is to-day suffering a serious shortage in fuel. China's mineral output has become a significant economic factor; while Japan is working overtime, experiencing somewhat the same era of prosperity that the United States has been enjoying. As to Germany, we may be sure that her mining industry, formerly highly efficient, has been the focus of much additional study, and that under the spur of necessity and beyond the influence of normal competition, mining operations have been extended to many low-grade deposits never before workable as ore.

The mining boom has of course stimulated those sciences that have to do with the treatment of the crude mineral products as they come from the mine—metallurgy, ore dressing, and industrial chemistry. The new and fairy-like "flotation method" of separating ore minerals from worthless rock by floating off the *heavy* particles by means of oily froths has in particular found this a favorable time for development; under

the balmy breezes of bonanza prices this infant has grown into a lusty youth of already notable achievements and even greater potentialities. Electric smelting, to cite merely one more example, has been forced past the experimental stage, and the past three years has witnessed the installation of more than one hundred electric furnaces, especially in Norway and Sweden, for the manufacture of steel alone, not to mention notable electrothermic developments along many other lines.

While the European War has sped up the production of gold, it has exerted a much greater effect upon the commercial movement of the metal. For the first time in history, this country has accumulated such enormous gold reserves that it has become not only the principal gold-holding nation of the world, but now has more gold than any other nation ever had. The world's supply of gold, exclusive of jewelry and works of art, is estimated at eight billion dollars, of which the United States now holds approximately three billions (2,700,000,000 on Nov. 1, 1916). Since December, 1914, the gold coming to this country has been equivalent to the production of the rest of the world during this period. In short, due to the war, the gold production of the world is finding its resting place in the United States. This situation is filled with grave concern for the future; its effect on the present, as a contributing factor to high prices, is obvious.

The impetus given the mining industry by the present war, however, can not be looked upon as an unmixed blessing. Apart from the destruction of mining activity in some sections, as in parts of Belgium, France and Roumania, and the serious setback given it in others, as in Australia, the economic loss involved in the total destruction of vast quantities of material, the existing supplies of which are limited, overbalances the financial gain and technical advance growing out of the war stimulation. The war has proved a serious drain on the mineral resources of the world in general and of the United States in particular, bringing the period of exhaustion of certain of these materials nearer. That, the people living in the fringe of depletion of such products will realize more vividly than we.

V

We have seen that war and mineral resources are intimately related; that mineral products are essential to the carrying on of war; that they have always been essential, but increasingly so; that they have, in certain instances, actually been the cause of war; and that in turn they are strongly affected by war

conditions. It remain now to consider briefly the situation of the United States as regards its mineral resources in event of continued war—an important phase of preparedness.

The mineral resources of the United States happily are extensive and varied. They are also well-developed. This country is not only the world's greatest producer of mineral wealth, but "possesses greater reserves of most of the essential minerals than any other nation." Moreover, thanks to the well-directed efforts of the United States Geological Survey, we know more about our mineral resources than does any other nation about its own, save perhaps Germany. The United States therefore is to-day better prepared as regards the *presence* of fundamental resources of war than is any other nation, better prepared in this respect, indeed, than she is from an industrial or human standpoint. But the problems connected with the exploitation and conservation of deposits now known, with the development of new and low-grade deposits, and the means for filling gaps in our present production are all peace problems that merely become more acute in time of war.

The value of the mineral production of the United States in 1913 was practically \$2,500,000,000. In that year she produced about 40 per cent. of the world's coal, 65 per cent. of its petroleum, 40 per cent. of its iron ore, 55 per cent. of its copper, 30 per cent. of its lead and zinc; and of its silver and gold she yielded 32 per cent. and 19 per cent., respectively.

The coal fields of the United States are inland, scattered, and distant from frontiers. Less than 1 per cent. of their total tonnage has been mined; they will last, even under increasing consumption, for several centuries. The incredibly wasteful methods of coal mining characteristic of earlier decades have been considerably improved upon; the chief waste now is the loss of energy during combustion and the failure to utilize more extensively the volatile portion for the manufacture of gas, ammonia, and coal-tar products. Radical changes in the utilization of coal are bound to come.

The petroleum fields of this country are likewise scattered, but those of California, producing two fifths of the domestic supply, are close to the Pacific coast. The life of the petroleum reserves is variously estimated at between twenty-five and one hundred years. Terrific waste has taken place in this industry; much is still going on. The production will be prolonged somewhat by the development of a suitable process for distilling on a large scale extensive deposits of oil-shale occurring in the west and perhaps lower-grade deposits in the east. The ap-

proaching exhaustion of the oil fields is already being felt in the climbing price of gasoline. The adoption of an oil-burning navy will prove a tremendous drain on the oil reserves of this country, and the question obtrudes whether a successful maintenance of our present naval program will not demand the control of the large oil pools of Mexico.

Eighty per cent. of our iron comes from the Lake Superior region. Lacking these immense deposits, our iron industry would be seriously, though perhaps not fatally, crippled. The unmined iron-ore of present workable grade in the United States is estimated to represent an eighty-year supply at the present rate of consumption; but low-grade deposits are present which under future conditions may be forced to yield for seven or eight centuries.

Of important mineral products, there are seven of which this country has no domestic supply *developed* to the point of satisfying her war-time needs.¹ These are potash, nitrates, manganese, tin, nickel, platinum and pyrite.

Potash is of peculiar significance, for heretofore our entire supply has come from the famous mines of Stassfurt in Prussian Saxony, a locality which indeed has long held a monopoly on the world's output of this material, so indispensable to modern agriculture and to many chemical industries. The exactions of the German Potash Syndicate caused the United States a number of years ago to realize the importance of developing a domestic source of supply, and consequently the government instigated a systematic investigation, which, accelerated by the cessation of imports during the war, has met with some success. At present, in addition to a small recovery made from a number of waste products, including the smoke from Portland cement plants, a growing production comes from salt lakes in California and Nebraska and from deposits of a potash mineral known as alunite under operation in Utah; while certain deep and surface brines and the giant sea-weed of the Pacific coast, known as kelp, whose ash runs to 30 per cent. potash, are under development and giving promising results. In addition, there are extensive deposits of silicate rocks ranging from 5 per cent. to 9 per cent. potash, which would furnish an unlimited supply, should a suitable chemical process be developed on an economic basis for making the extraction, now too costly for practical results.

Nitrogen, the basis of practically all explosives, and like potash essential to chemical technology and to agriculture, is

¹ A stringency is felt in regard to a few other important minerals, but it would carry us too far afield to consider them here.

drawn largely from deposits of sodium nitrate in northern Chile. Unlike most mineral occurrences, this seems to be unique; no similar deposits of consequence are known elsewhere, and hence Chile has been able to maintain a world monopoly on this valuable salt. The United States alone imports yearly over twenty millions of dollars worth of this material, a little over one third of the total exports. While abundant in the atmosphere, nitrogen is so inept at chemical combination that a large supply of electrical energy is required to obtain it from this source, a serious disadvantage in America where water power is not fully developed and electric power is at a premium. Nitrogen, however, is an important constituent of coal, most coals carrying over one per cent. of this element. But this nitrogen is returned to the atmosphere when the coal is burned, and only when the coal is distilled or converted into coke in a modern type of oven known as the by-product or retort oven is this valuable constituent recovered in the form of ammonia, which may be changed by a process now becoming successful into the nitric acid required by the explosive industry. A ton of coal so treated yields \$1.50 in ammonia, gas, and a tarry residue convertible into drugs, dyes, explosives, etc., while the heat-producing portion is left behind as coke, which may then be burned as fuel, or employed, as most of it is, in the iron blast-furnace. The United States in 1913, the last year unaffected by war conditions, produced from coal \$8,000,000 worth of nitrogen products, but this figure would have been nearly \$30,000,000 had the nitrogen been recovered from all the coal coked; and much greater had a higher percentage of the total coal mined been distilled before combustion. But in spite of these facts, Congress in 1916 appropriated \$20,000,000 for the construction of a plant for obtaining nitrogen from the atmosphere, but made no provision for stimulating a more extensive recovery of this element from coal—a one-sided action inimical to proper progress as tending to discourage the by-product development. In other words, we are paying \$20,000,000 to recapture from the air part of the \$20,000,000 worth of nitrogen yearly sent into it by wasteful coking methods!

Manganese is essential to the manufacture of steel. No substitute is known for it. Although there are many low-grade deposits in the United States, this country in 1913 imported nearly 90 per cent. of its supply, getting part in the form of an iron-manganese alloy from England and Germany, and part in the form of manganese ores from Russia, India and Brazil. The war cut off practically all the foreign sources except Brazil

and of course stimulated the output of that country. But a shortage was created in the United States, which became acute; by April, 1916, the price was ten times the normal. The situation is now better, but a serious stringency is still being felt as the response of local ores is slow; were we suddenly isolated by the present war, "we should immediately need more time to bring the production of manganese up to our requirements than we should to create an army." In preparation for war, therefore, the problem of manganese is one of prime importance.

The United States is the greatest user of tin among all nations, her importation in 1913 being \$46,900,000, about two fifths of the world's output. But she mines an insignificant quantity and that comes wholly from Alaska. Her supply is derived chiefly from Europe where ores from the Straits Settlements, from the island of Banca, off Sumatra, and from Bolivia come for smelting. Bolivia, with her increasing importance as a producer of tin ore, should be looked to as a direct source of crude material to be smelted here; and this has already been done to a limited extent. No adequate development of a domestic source of tin seems possible.

A small quantity of nickel is recovered in this country as a by-product in the electrolytic refining of copper, but there is no production from nickel ores, although nickel minerals are known at a number of localities. The world's nickel comes almost exclusively from Ontario, Canada and New Caledonia, most of the product of the former being shipped to the United States for refining before distribution and use.

Platinum, that rare and unique metal so essential to chemical research, is in strong demand throughout the world. In 1913 Russia produced about 93 per cent. of the world's supply, while the undeveloped deposits of Colombia contributed nearly 6 per cent., and the United States less than $\frac{1}{2}$ per cent. The domestic production may be increased somewhat, but the more pressing problem is the conservation and proper use of the metal already in circulation.

The unusual shipping conditions arising out of the unrestricted submarine warfare have practically cut off the supply of pyrite from Spain, upon which the sulphuric acid manufacturers were largely dependent; a situation rendered serious by the large quantities of sulphuric acid required in the industries and for the preparation of phosphate fertilizer and explosives. The stringency is being tided over by the use of small reserves of pyrite on hand; and much attention is now being directed to the development of numerous low-grade pyrite and related de-

posits in the East, etc.; but the pyrite problem, while soluble, is not yet solved.

Preparedness is a complicated matter, involving the training of men, the organization of industry, the assembling of raw materials, and, behind, all the application of science to every phase of the problem. Preparedness, limited to the thesis of this essay, must *anticipate* the organized use of every mineral resource essential to war, which means practically every mineral resource. This involves study, investigation, exploration, organization, and conservation—rigorous, complete, scientific—which must be inspired and guided by the government. Much has already been done; much remains. And as mineral resources in the future will be more significant in determining the balance of power among nations than they are to-day, this problem becomes increasingly important at time goes on.

The writer hesitates, in conclusion, to make specific suggestions, as the manifold aspects of the problem can be adequately encompassed by no single individual. Yet he ventures to mention a few lines of activity, along which immediate action would yield a good return, whether peace comes soon or war continues. A detailed study of the mineral resources of the United States should be made from a military standpoint; the activities of the Geological Survey and the Bureau of Mines should be increased by enlarged governmental support; the topographic map of the United States as well as the geologic map should be pushed to completion; an adequate domestic supply of potash, nitrogen, manganese, pyrite and nickel should be rapidly developed, under governmental aid if necessary, and a thorough search instigated for tin and platinum; the War Department should engage a geologic staff; wastes should be eradicated from the mining industry by drastic means; conservation should be more thoroughly studied and more extensively applied, under governmental direction, in the light of military necessity; the antiquated mining laws of this country should be revised; a consistent plan of developing the public mineral lands, probably by a system of leasing, should be put into operation; governmental exploitation of public oil lands for military uses should be undertaken; the burning of crude oil and of uncoked coking coal should be strongly discouraged, if not actually legislated against; the further utilization of platinum for ornamental purposes should be heavily penalized; and finally the spirit of scientific research should be fostered in every way and be given its due place in the nation's life.

¹ This has recently been undertaken.

SCIENCE AND AN ORGANIZED CIVILIZATION¹

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SO pervasively is science woven into the very fabric of western civilization that no appeal is necessary in behalf of extending its sway or enhancing its security. Everybody now recognizes that agriculture, manufacture, transportation, war, sanitation and medicine simply could not exist in the modern sense but for the objective sciences.

Urgent questions there certainly are as to particular ways of making the several sciences still more widely applicable, and still more effective for the interests mentioned.

But vast and noble as are these services of science, yet when science is regarded from this standpoint chiefly, it connotes technology rather than a mode of expression of the human intellect and will and hand *per se*. And we must recognize that, in so far as science is thus restricted, it is rather an instrument of civilization than somewhat of the real essence of civilization.

My part in to-day's program is to exhibit science as an interpreter of, and a participant in, the deepest life of civilization itself rather than as an instrument of civilization. But before proceeding to the task proper, I must shield myself with a few sentences against the possible inference that my attitude toward applied science is one of lukewarmness or even of deprecation. So remote from me are such feelings that I do not regard any science, however "pure," to have attained full worth and dignity until application to human welfare of some sort

¹ One of four addresses presented in a symposium upon "Coordination and Cooperation in Research and in Applications of Science," held during the meeting of the Pacific Division of the American Association for the Advancement of Science at Leland Stanford Junior University, April 5 to 7, 1917. The other addresses presented upon this occasion were:

"The National Research Council as an Agency of Cooperation," by Arthur A. Noyes, Director of Chemical Research, Throop College of Technology, Pasadena, California.

"Plans for Cooperation in Research among the Scientific Societies of the Pacific Coast," by J. C. Merriam, Professor of Paleontology, University of California, Berkeley.

"The Applications of Science," by William F. Durand, Professor of Mechanical Engineering, Leland Stanford Junior University, California.

has been found for it beyond the intellectual interest it may have to a few intense delvers in each particular specialty. The kernel of my view touching this matter is that all scientific investigation, no matter what may be done with the results after they are attained, must be pure in the sense that it must throb with devotion to the *pure truth* sought, otherwise it will be frail and misshapen, and timorous of the light of the common day. The publicly expressed policies and the accomplished work of the research institution for which I am in a measure responsible constitute, I venture to hope, evidence that my views on this matter are not entirely theoretic.

The initial contentions of the argument I present to-day are two: no federation or compact of nations can possess the elements of measurable permanency and usefulness the main roots of which do not reach clear through the layers of social custom, formulated law, and ordinary political organization and convention, and penetrate deep into the nature of man himself; and second, that such an understanding of man as this implies is the province of science, primarily. Biological anthropology, with special regard to its psychological aspect, is the only source of material for a proper foundation on which to erect a truly useful and durable international structure.

I am familiar with the opinion held by many jurists, statecraftsmen, publicists, teachers, ministers of religion and philosophers that they alone are the custodians of man's higher welfare, and that the occasional incursions of science into their provinces are more productive of harm than of good. Many who speak for these groups are particularly outspoken in the present distracted time against the effort to "drag biology into human affairs." Now we men of science must acknowledge fully and openly that this feeling toward science and toward us as students and apologists of science has much to justify it in certain ideas and undertakings of ours. The gigantic and rather easily won successes scored by many branches of science in these later decades have tended to make many scientists impatient, even scornful of that rigor and comprehensiveness of thinking which for centuries have characterized mathematics, formal logic and the main schools of western philosophy. Nor have the sciences, while winning for themselves institutional place and communal standing, kept themselves above that very same arrogance of learned caste for the overcoming of which at an earlier time science had to join combat with the old disciplines. Great and powerful, and at heart noble as is the science of our day, it yet is distinctly

poorer than it formerly was in that it has lost something of that manly boldness and the chivalry of its heroic periods.

But nothing is more patent once any one, whether humanist or scientist, tutors himself broadly and reflectively, than the fact that to maintain humanistic learning in complete and splendid detachment from scientific learning is no more possible than it is to maintain the dining-room of a household in complete detachment from the kitchen. The statesman who would exclude the biologist and the anthropologist from any voice in problems of government and social and industrial justice would be in like case with an orange producer who would exclude the botanist and horticulturist from a voice in the problems of good and abundant oranges. Oranges and oranges for dividends, the orchardist might argue, is what he is after, and men who busy themselves with such things as roots and wood and leaves and soil are too remote from his interests to figure in his calculations.

To all those who in our day proclaim the theory that science is really something apart from the deeper, the spiritual welfare of humanity, I call attention to a historical fact which appears very remarkable when viewed in the light of that theory. The fact referred to is that beyond question many of those writers on society, government and law who have spoken to us out of the earlier and intermediate centuries and who have influenced civilization most profoundly have avowedly taken nature and the nature of man as their starting point and constant base of reference.

I have recently given offence, I fear, to friends who are professionally occupied with the literature and philosophy of ancient Greece, by affirming that it is impossible for any one to understand Aristotle either in letter or spirit who does not know him as a naturalist—as a zoologist. Acquaintance with the “Parts of Animals” and the “Generation of Animals” and the “History of Animals” is, I insist, as indispensable to an understanding of the “Politics,” the “Poetics” and the “Ethics” as is acquaintance with the Constitution of the United States to an understanding of our national and state governments.

And who that has dipped even his finger-tips into the learning and the thoughts with which Cicero enriched the world can have missed being impressed by his appeals to what, following the Greeks, he calls “the first natural impressions”? *De Finibus* is especially permeated with such phrases as “the principles of nature.”

Probably no single author illustrates the point quite so vividly and dramatically as J. J. Rousseau. A recent commentator on Rousseau has expressed, in effect, the opinion that probably no other author whatever, modern or ancient, has put so powerful a ferment into social and governmental theory as Rousseau. And his own story of his life, as told in the *Confessions*, reveals even more clearly, if that is possible, than his formal treatises, the extent to which his exhortation "back to nature" was basic to his whole scheme. And of far more than historic interest for us in this country to-day is the fact that the entire sociological and political school of eighteenth-century Frenchmen of which Rousseau is, I believe, usually held to be the climactic figure, was first and foremost a nature-of-man school. This fact has, I say, more than a mere historic interest for us, in that our own national ideals and ideas send their roots directly back into that school, especially through Thomas Jefferson.

But the author to whom I find it advantageous to give a focal place in my discussion to-day is Hugo Grotius, the great Dutchman generally accepted as the father of international law. Few things seem to be more significant for us now than the circumstances under which his epochal book, "*De Jure Belli ac Pacis*," was composed, and his appeal to human nature in this work.

Listen to the full title of the book put into English: "The Rights of War and Peace, including the Law of Nature and of Nations." The Law of Nature and of Nations! Is there one in this audience who has read somewhat at length in the writings of the fathers of our nation to whom this phrase is unfamiliar? Whether the expression originated with Grotius or not I do not know, but certain it is that he made it his very own, and gave it a life and meaning that it had never had before. As one goes through the pages and chapters of his book, he becomes aware that an equally true title for it would be "The Law of Nature in its relation to War and Peace."

And what is the kernel of the whole matter? That the law of nations is essentially the same thing as the law of nature, and that the law of nature, especially as it expresses itself in the nature of man, is the supreme law of the universe, even the Divine Law not excepted. God Himself, Grotius points out repeatedly, is unable to set at naught the law of nature. Divinity, he naïvely reminds us, is incapable of making five out of twice two.

Reflect now on the circumstances under which the Rights of

War and Peace was produced. The work was written in the midst of the Thirty Years' War, and concerning the general situation the Honorable David J. Hill has said:

Looking about him at the general havoc which war had made, the nations hostile, the faith of ages shattered, the passions of men destroying the commonwealths which nourished them, Grotius saw that Europe possessed but one common bond, one vestige of its former unity—the *human mind*. To this he made appeal and upon its deepest convictions he sought to plant the law of nations.

With this quotation another phase of our discussion is reached. The havoc of great war with its wreckage of former unities and of faiths affected Grotius as apparently it tends always to affect men. It left visible to him only one common bond among the peoples of Europe—"the human mind"—in Mr. Hill's language.

Even so with us to-day, the world cataclysm filling our eyes, our ears, our intellects and our hearts. Human nature stands before us almost stark naked. Hardly any of the former garments of political, social and industrial order hide its form. And so like Grotius we ought to scrutinize that naked body as under normal conditions it is hardly possible to scrutinize it.

And here comes a measure of uniqueness in my contention. Such a time of shattered custom and law as this is exactly one which reveals the need of, which gives the opportunity to, science. In former centuries, before great differentiation of the province of learning had taken place, the doctors of law might well undertake to study man himself after the garments of law were stripped from him. Not so to-day, when the field of learning is parcelled among so many doctors. Those of science, especially those of biological anthropology and psychology, and not alone those of law and normal society, are designated by the problems themselves and by the character of our era to play a conspicuous part in the making of peace and the reestablishment of order when the time for that business shall come.

To show more specifically the ground on which this contention rests, and to indicate two or three points at which the service of science is especially urgent, is the task for the few minutes remaining to me. What I have to say under this head may be fittingly introduced by the following quotation from Grotius:

Aristotle, taking a description of man from his peculiar qualities, makes him an animal of a gentle nature, and in another part of his works, he observes that in considering the nature of man, we are to take our likeness from nature in its pure and not in its corrupt state.

The train of reflection initiated by this statement is this: The principle of procedure followed by Aristotle and less faithfully by Grotius in dealing with man on the basis of his fundamental nature, is right as to broad outlines, but viewed in the light of modern natural history and anthropology is wholly inadequate as to details. Let me explain. The principle is right in so far as it "describes man from his peculiar qualities," using Grotius's phrase, and in so far as it "takes our likeness from nature in its pure and not in its corrupt state," speaking again in Grotius's phraseology. The inadequacy appears under two aspects, one pertaining to substance, the other to form.

Before treating of these two aspects specifically it will be well to state the case in a form which brings it to our own times and conditions: The whole vast body of discussion of man under western civilization, as this appears in writings on society, government, law, ethics and the rest, is radically defective in that it rests on no adequately scientific definition of man. Incalculably far-reaching as this criticism is, the warrantableness of it becomes clear and unescapable once the matter is approached from the direction from which Aristotle, and in part Grotius, approached it, and is followed through on the basis of later progress in the sciences of man.

To take up now the technical or scientific view of the matter spoken of a moment ago as having two aspects, one of substance, the other of form. This leads us to requisition that great province of natural knowledge in which Linnæus is the dominating figure, namely, that of the systematizer; and the equally great province in which Charles Darwin stands pre-eminent, that of inquirer into the origin of kinds of living beings. Only the most vital spots in the gigantic situation can receive attention here. Let us remind ourselves of Huxley's eminently just characterization of Linnæus as the supreme lawgiver of living nature. Reflect on what he did to advance man's interpretation of himself over what Aristotle had done. Aristotle had rightly, though only partially and wholly empirically, defined man "from his peculiar qualities," and had seen that logical consistency demanded that these peculiar qualities should have reference to man "in his pure and not in his corrupt state."

But it remained for Linnæus to bring out that this mode of defining man fixed his place not empirically or arbitrarily, but naturally and inevitably, in the vast *system* of living nature, and that it placed him at the head of this system. Paltry though Linnæus's contribution to man's understanding of him-

self was as compared with Aristotle's, when the *substance* of it is concerned, because of the *form* he was able to impress upon that substance his service to humanity was very great, for it amounts to a veritable natural revelation to man of what his place is in the system of the universe. I am convinced that his service in this has been rarely recognized with sufficient fullness either by scientists or humanists. Think a moment about what he really did on the basis of the knowledge that had been accumulated concerning the physical characters of animals and man. He was able to recognize man not only as belonging to the animal kingdom, but to the class *mammalia*, to the order *primates*, and to assign him to a genus, *Homo*, in that order. Then on the basis of man's "peculiar qualities," reverting again to Grotius's statement of Aristotle's method, he undertook to define the kind, or species man, and subdivide it into several sub-kinds or races. And here comes the point which, so far as man's own welfare is concerned, is most vital, though it is usually regarded in the lightest way or not at all, especially, I fear, by present-day biologists. What "peculiar qualities" of *Homo sapiens* were they to which Linnæus appealed in his efforts at systematizing the species? Why, those of habit, of location, of educability, of temperament, of esthetic impulse, of relation to law and government, and of rational and moral life. All this is set down after the usual synoptic fashion followed by Linnæus in the "*Systema naturæ*." So much for what this lawgiver of living nature builded into the great edifice of man's understanding of himself: On the basis of his physical attributes he assigned man to the natural order; and on the basis of his civilizational or spiritual attributes he isolated man *within* that order, and subdivided him into lesser groups.

Turn now for a moment to what that other master builder, Charles Darwin, put into the same edifice. Great as was Grotius's regard for and adherence to the laws of nature, he still was unable to conceive that some of man's most distinctive attributes could have come from this source. "Who for an instant would say," he remarks, "that the Christian precept of laying down our lives for others was an obligation of the law of nature?"² Yet exactly this obligation Darwin showed to inhere in the natural law of organic creation and existence, for he showed in a manner which has carried conviction to all critical minds that man in the whole scope of his being is a natural product, and he also accepted the criterion of self-sacrifice as the most positive of all for man's nature.

² "The Rights of War and Peace," Chap. II., Sec. VI.

I must pause a moment to call attention to the meagerness of understanding of Darwin's position in this matter. His own words leave absolutely no room for doubt. The opening sentence of Chapter III. of the "Descent of Man," the beginning of the discussion of the moral sense, is as follows:

I fully subscribe to the judgment of those writers who maintain that, of all the differences between man and the lower animals, the moral sense or conscience is by far the most important.

Nor does he leave us in the least doubt as to a part at least of the meaning he attaches to moral sense. He says:

This sense, as Mackintosh remarks, "has rightful supremacy over every other principle of human action"; it is summed up in that short but imperious word *ought*, so full of high significance. It is the most noble of all the attributes of man, leading him without a moment's hesitation to risk his life for that of a fellow-creature; or, after due deliberation, impelled simply by the deep feeling of right or duty, to sacrifice it in some great cause.

With the exceedingly important matter of Darwin's effort to bring this attribute of man into harmony with his hypothesis of survival of the fittest we are not now concerned. Enough for this presentation to know that he recognized the attribute in the fullest possible way, and held it to be as natural to man as any of his other attributes.³

From these excursions into the ideas and methods of Aristotle, of Grotius, of Linnæus and of Darwin, we are now prepared to extract from the vast accumulation of knowledge, ancient and modern, of the natural history of the human species, a summary definition of that species which would be a fairly adequate foundation for the discussion of and the practical conduct of man under civilization.

The most distinctive thing about this definition as compared with definitions, expressed or implied, that have usually passed muster, is its recognition of the necessity of being comprehensive—of including all the major groups of attributes of man—instead of focusing on one group with the theory that these are cardinal while all the others are secondary and tributary to it. In other words, the revised definition is made in accordance with the maxim "neglect nothing" which is of growing importance in taxonomic biology. Leaving aside the purely physical peculiarities merely for the sake of brevity and on the assumption that they are obvious to all, and without pretending

³ Dr. George Nasmyth ("Social Progress and the Darwinian Theory," New York, 1916) has dealt more adequately with this aspect of Darwin's teachings than has any other author with whom I am acquainted.

to exhaustiveness, the definition runs somewhat thus: Man is a speaking, esthetic, religious, thinking, political, economic, moral and idealizing animal.

A cardinal thing about this definition is not merely its comprehensiveness, though that is greatly important, nor yet the finality of delimitation and sequence of the several groups of attributes; but the indubitable reality, and the basic functional interrelation of all the groups.

And do not fail to notice that while the assertions that man is an eating, propagating, mating, fearing and fighting animal are true also, they can not be included in the definition of man *as man* for the reason that they are equally true of all animals. We here see again the great importance of the natural history method; that is, the method of defining organic beings by *taxonomic groups*, first clearly recognized by Linnæus. Definitions of this sort are characterized as much by what they *exclude* as by what they *include*. Even a partially adequate treatment of this matter would necessitate a whole course of lectures. I can now do no more than assert dogmatically that a prodigious amount of not only false but, scientifically viewed, foolish theorizing about civilized man has been carried on because of failure to recognize this principle. For example, the "wolf" theory of modern business and politics comes under the latter stigmatization. A man and a wolf are animals of very different nature—of widely separated taxonomic rank, so that from the natural history standpoint it is simply ridiculous for the species *Homo sapiens* to try to act not in accordance with its own nature, but in accordance with the nature of some other species, as a wolf. How does it happen, one may ask, that men should have hit upon the wolf rather than upon the hog in attempting to shunt moral responsibility for their deeds from themselves to their animal natures? From a purely scientific standpoint one course is as justifiable as the other. A man might exactly as well rely upon his odor-producing peculiarities in his "struggle for existence" because a skunk does so, as to rely upon his rapacity because a wolf does. To taxonomic biology these cases are entirely parallel.

From the many lines of possible consideration which naturally radiate from this perception of the nature of man I select only one with which to end this paper. That is the radius which starts from the part of the definition which recognizes man to be an economic—a wealth-accumulating—animal. This is chosen for the reason that it seems to me to be the most important of all in this particular world crisis. Despite the

obviously enormous importance for the future of international relations, of man's political nature, his economic nature is still more important.

I am unable to understand how any measurably intelligent and thoughtful person can fail to see the futility of hoping for and working in behalf of immunity from military war among civilized peoples so long as these same peoples conceive industry and commerce as being in their essential nature a sort of war. If all the nations of the world, as well those engaged as those not engaged in the present military struggle, are in very truth planning for the "war after the war" about which we have heard so much, proposals looking toward permanent peace among the nations are as futile as would be proposals to reclaim the tropical lands of the earth by so shifting the earth's axis as to make those lands temperate instead of tropical.

I fully agree with the view so admirably expressed by President Wilson in his epochal war message that no basis for a peaceful and mutually advantageous compact among nations exists so long as the present German theory of the state prevails in even one powerful member of the "family of nations."

But even were all government claiming responsibility to itself and God alone done away with, the civilized world as now constituted would be a long way from insured against devastating wars. Men's fighting instincts do not depend alone or even chiefly on the form of government under which they live. Now, since economic needs and tendencies are not less strong under popular than under autocratic rule, and since the group of attributes upon which economic life has depended has dominated all other groups in the later decades, the good of mankind for the future is really as much dependent on bringing these attributes into proper subordination and correlation with the other major human attributes as on anything else whatever.

Speaking in terms of organic evolution, this world war is a time of metamorphosis of world civilization. If the titanic transformation taking place before our eyes shall be progressive rather than retrogressive the economic system of civilization will, we may confidently predict, emerge no less profoundly modified than will the governmental systems. "This commercial age of ours" must be approaching its end if civilization is passing to a higher plane. Economism, as several generations have understood the word, does insufferable violence to some of the profoundest instincts, the most precious interests of human life, and can not survive in that higher civilization

toward which the imagination and the ideals of all thoughtfully good men are turned.

What part has science to play in the yet unacted portion of the mighty drama? That is the specific question to which this address would contribute something. An attempt to answer the query in detail is neither possible nor necessary in this place, but a reply in broadest outlines is ventured.

1. Biology may undertake to convince the world that the prevalent custom of invoking the doctrine of the survival of the fittest in palliation, even in justification, of unhuman methods in business, politics and war rests on a deep misunderstanding of the evolutionary processes.

2. Anthropology may undertake to convince those historians, economists and publicists who have been committed to the extreme materialistic conception of human history and the extreme economic theory of human society that these doctrines imply a definition of the human species which is found to be very inadequate and largely fallacious when viewed in the light of natural history.

3. Chemists, physicists, geologists, agriculturists and breeders of plants and animals may undertake to convince the world that the latent resources of the lands and waters of the world are sufficient to insure the continued progress of our species in civilization, provided civilization be understood to consist in the harmonious growth and interplay of all the great groups of attributes which differentiate man most sharply from other animal species, and provided that the resources of the whole earth are utilized in accordance with the dictates of common wisdom and common justice and developed through the applications of science. And finally,

4. Scientific men and women of the whole world might, it would seem, unite in an effort to convince the statesmen, diplomatists and lawyers upon whom alone, according to precedent would fall the stupendous task of making peace and re-establishing political and economic and social order at the end of the war, that the voice of science ought to be far more definitely and authoritatively heard in the business than it ever has been before, this voice to be particularly invoked in the two supreme problems of colonial possessions and the use of the seas.

THE APPLICATIONS OF SCIENCE¹

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THIS assemblage needs no definition of science; nevertheless for our present purpose I shall characterize science as the disclosure of the facts of nature, and the orderly study of such facts with a view to the establishment of their interdependent relations.

If we ask why we should concern ourselves with the examination of the facts of nature or with the interdependences which seem to connect them in the relation of cause and effect, we may find at least two fundamental reasons and these are:

1. As a response to the innate curiosity with which we are endowed regarding the universe, its constitution, phenomena and laws of evolution: or otherwise in response to the joy of achievement and conquest which we feel in being able to enter some little way into the *arcana* of nature.

2. In order that the phenomena disclosed or the laws established may be applied in the service of humanity.

It is to this second purpose that I am to specially direct your attention for a few moments.

In nature and by themselves all facts are of equal importance or value. Or, rather, the concept of value or importance does not and can not attach to a fact or a law of nature as such. Rather, the facts and laws of nature are beyond value and do not admit of comparison as to relative importance. It is only as they come to be applied that they take on relative value or significance. This value or significance is therefore something wholly extraneous to the fact or law itself, something contingent on the particular circumstances which surround its application to the demands of civilization.

Again it will perhaps be admitted, as a broad generalization, that until the facts of science have reached the status of application in the service of humanity, they have not reached their widest plane of significance, nor have they justified to

¹ An address presented in a symposium on "Coordination and Cooperation in Research and in Applications of Science," held during the meeting of the Pacific Division of the American Association for the Advancement of Science at Leland Stanford Junior University, April 5 to 7, 1917.

the full the human energy which may have been expended in their disclosure. The progressive widening of the scope and significance of a fact of science may be noted in three stages.

1. Its discovery or establishment by the worker in some field of science. So long as it does not go further, this fact is known only to its discoverer and to the omniscient intelligence pervading nature. It gives the discoverer a thrill of the joy of conquest; or it may awaken feelings of awe or wonder at the sublime harmonies of nature.

These, however, are purely subjective. They relate to the discoverer alone. The significance of the fact has not yet passed beyond the boundaries of his being.

2. We may next suppose that the fact is spread abroad and made a part of the common stock of scientific knowledge. Its significance now becomes greater. It helps all workers in science to better understand the secrets of the universe; it may help humanity broadly toward a higher and nobler appreciation of the works of nature. The significance of the scientific fact is thus enormously widened and deepened. It has not yet, however, passed beyond the domain of intellectual or esthetic appreciation.

3. If now in the third stage we suppose that some application of the observed fact or established law may be made which will aid in curing disease, in giving us new comforts in the home, in rendering life and its activities safer or fuller, we have the realization of the final stage in the widening significance and value of this fact of science.

We may perhaps imagine Oersted's intellectual gratification in developing a coherent formulation of the laws governing the mutual relations of a magnet and an electric current.

We may likewise imagine the intellectual satisfaction with which the scientific world of his day received this formulation. The significance of Oersted's work, had it remained bounded by these results, however, would fall far short of the significance in the world of to-day, of the electric motor, with its countless points of relation to our comfort, safety, pleasure, and appreciation of the content of life.

We may imagine the spiritual exaltation with which Crookes about 1880 glimpsed his so-called fourth state of matter. Those of us above forty years of age will probably remember the awed and exalted state of mind with which we entered into some knowledge of his work.

However, had Crookes and others working in the same and allied fields gone no further, and if no application in the service

of humanity had been made of the early observations of Crookes, Roentgen, Becquerel, the Curies and others, then would the influence on the human race or the significance to it of these scientific discoveries have been small indeed compared with the present significance of the cathode ray and the various radioactive substances, a significance which seems likely to grow in the future in ways and to an extent of which we can gain no present vision.

Illustrations might be multiplied beyond measure, but it is unnecessary for our purpose. It will, presumably, be admitted that until a fact of science has realized some useful application in the arts of life or in the service of humanity, it has not reached its highest and widest significance. Short of such application it stands indeed as a conquest gained in the struggle with nature, it stands as a fact of mental achievement, it stands as a fact in relation to the intellectual life of the discoverer and perhaps of the intellectual lives of thinking men and women the world over; but it has not yet reached the status where it may be counted as a factor in the material or outward content of life, and to this extent at least it has failed of realizing the full measure of its significance to humanity.

I should perhaps note at this point that not all facts of science seem equally applicable to the immediate service of humanity—at least in outward and material ways. Indeed many of the facts of science seem hopelessly removed from the opportunity of application to the arts of life; for example, portions of advanced pure mathematics and much of astronomical research. This does not imply that for this reason such fields of science are the less worthy of intensive cultivation than those where the opportunities of application seem more probable. In the first place no one may dare predict the future significance of any fact of science, no matter how remote it may seem from useful relation to the needs of humanity at the present moment. It is the glory of the worker in pure science that he is not concerned with the question of application as such; *that* he leaves to others and to the future. He is endeavoring simply to uncover some portion of God's truth and to place it on deposit in the great storehouse of scientific knowledge, whence it may haply be drawn in the fullness of time to serve some purpose now far below the horizon of our thought.

All this, however, does not affect the truth of the broad thesis that when such facts of science shall have been drawn out of the storehouse and applied in the service of humanity, then will they reach the full measure of their potential signifi-

cance to humanity and then will they have fully justified the energy expended in their pursuit and disclosure.

And so to close this phase of the discussion I repeat that a fact of science until it has been applied in the service of humanity is potential in its relation, at least to our outward and material life. When it has reached the stage of useful application, this potential relation or significance has been transformed into an actual and real significance. It has then taken its place as a factor in the life of the human race.

The problem of the application of science may be phrased as the problem of bridging the gap between science on the one hand and the needs of humanity on the other.

We find that the problem thus broadly stated divides under perhaps two typical forms or types:

1. Given a fact of science, what are its useful applications?
2. Given a demand or need presented by the arts of life (using this term in its broadest sense), what facts of science may serve as significant factors in meeting the demand or in supplying the need?

The history of science with reference to its application in the arts of life shows abundant illustration of both types of problem, while naturally many cases are of an intermediate or mixed type.

In particular the second type presents two variations: (*a*) Where the needed facts of science have presumably been already developed and are stored away ready for use on demand, and the problem becomes simply that of finding or identifying them among the vast store open for inspection. (*b*) Where the needed facts of science have not been developed and the problem becomes that of organizing and directing an investigation in science along specific lines and with reference to the solution of a specific practical problem.

The two factors which are most likely to be of significance in the first typical problem are:

- (*a*) Imagination or vision.
- (*b*) Wide acquaintance with the needs represented by the arts of life, especially when expressed in terms of their scientific factors or elements.

For the problems under type two the factors which are most likely to be of significance are:

- (*a*) Wide acquaintance with the results of scientific research along lines likely to stand in a fruitful relation to the practical problem in hand.

- (*b*) Such degree of vision or imagination as will aid in

identifying such scientific facts or relations as are likely to prove of special help in connection with the particular problem in hand.

(c) Resourcefulness, energy, persistence, patience, capacity for analysis, synthesis, deductive logic, and all the other qualities of mind and character which we associate with the successful worker in special fields of science.

With regard to these typical problems a few observations.

The first problem may arise in connection with the discoverer of the fact or relation. The fact itself having been established, the question of its possible application may arise. It is an interesting thought that, purely as a matter of probability, the chances are, I believe, overwhelmingly in favor of the existence of some, perhaps many, direct and useful applications in the arts of life, even in the stage of advancement of the present day. It is a further thought of the deepest interest that thus far, at least, we have developed no scientific method for establishing the connection between the facts of science and their potential applications. As a broad fact or at least as a high probability we may say that the application doubtless exists: how may we discover it.

To our present contracted view it seems to call for what I often like to term the all-seeing eye; an intellectual eye is implied, of course. If we may postulate such an eye, and this is equivalent to postulating omniscience, we may picture this eye roving over the field of human endeavor with special reference to what I have termed the arts of life, and unerringly resting on those arts, or on the problems connected with such arts, as would offer a field for the helpful application of the fact of science in question. But, alas, we have not attained to this stage of evolution. Rather we are looking through a narrow aperture with clouded vision and can only make out imperfectly here and there uncertain features of the landscape which lies before us. To leave the figure of speech we need some means of approaching an orderly study of method, whereby relations between facts of science and problems of life may be more readily correlated.

With vision or imagination and some acquaintance with the problems presented by the arts of life, applications may be found, but the whole process is, for the most part, without method and depends on a fortuitous combination of happy circumstances rather than on scientific procedure. And so we conclude that in perhaps the most important of all possible scientific problems, that of the application of the results of

scientific work to the arts of life, we are wholly without a scientific method. Why should there not be a kind of super-science, a science which should have for its purpose the correlation of the immediate results of scientific work with the arts of life and thus the realization, at the earliest moment and in the fullest degree, of the potential value of the results of scientific work?

With regard to the second problem the condition is much the same as with the first. The demand here is for some fact of science applicable to a specific problem arising in connection with the arts of life. Here again the interesting thought occurs that in all human probability there now exists stored away and perhaps lost sight of in the storehouse of science, some fact, observation or correlation which will furnish the solution desired, or at least serve as an important factor in the prosecution of the problem. This is a reflection over which we may well ponder, restive at the thought that beyond all human probability there are now stored away in the annals of science facts of observation or generalizations in the form of laws which would have fundamentally important applications to specific problems now pressing for solution. These problems are before us and engage our attention. The arts of life urge speedy results. The necessary scientific work has perhaps all been done and the results are stored away beyond the scope of our immediate vision. How deplorable the situation. Why have we pursued science with such zeal, and taken no pains to provide for the better utilization of the facts when once disclosed?

The situation results further in the most serious economic waste. It results in the rethreshing of old straw, in the rediscovery and recataloguing of the facts of science when once should have been enough.

Is there not some way, when once a fact of science has been disclosed, of so cataloguing it and placing it on exhibit that it will not be necessary to rediscover the same fact a few years later, when there may arise some problem in the solution of which it must play a significant part?

It will be said, and with truth, that oftentimes the rethreshing of the old straw and the rediscovery of the already known fact arise from indolence or from negligence to search the records for such material as may be found. This is often the case. It is true, on the other hand, however, that there is urgent need for improvement in our system of keeping the record, and also that the scientist best adapted perhaps to work

out the practical problem is not always the best adapted to make a search of the record for the facts of science which may be of aid in dealing with the problem.

What seems to be needed is the development of a science of the use of science—a science whose purpose shall be the saving of waste energy in searching for scientific facts or principles applicable to specific problems, and likewise the development of economic and effective methods in seeking for useful applications of the elements of scientific knowledge.

The practical question immediately arises, as to the possibility of realizing anything effective in the way of such a science. What should be its factors, what its methods of procedure?

The answer to these questions requires more wisdom than I can command, but some few items, at least, are fairly obvious.

Quite aside then from the question of practicability, let us seek some of the more obvious elements of such a science. Among these the following may be noted:

1. A clearing-house or classified storehouse for scientific knowledge.

2. A clearing-house or classified storehouse for the diverse needs of humanity.

3. A staff of scientific workers whose duty it shall be to gather, analyze and prepare scientific data in various ways with reference to the development of points of application with the needs of humanity.

4. A staff of workers whose duty it shall be to gather, analyze and prepare in various ways data relating to the needs of humanity and with special reference to the development of relationships with the underlying scientific facts.

5. A staff of scientists whose duty it shall be to work with the material prepared by these corps of workers and whose energies will be directed toward the development of relationships between these two classes of materials, the facts of science on the one hand and the needs of humanity on the other.

The mere statement of this schedule of fundamental elements of such a science will bring a smile, perhaps, by reason of its impracticability, at least at the present time and in any large sense. The field seems too great to attempt its compass by any corps of workers of which we can readily conceive. When we consider, on the one hand, the existing facts of science, together with the generalizations and principles or laws which are intended to correlate them, and on the other the needs of humanity as expressed in matters to which science might stand

in a helpful relation—when we picture for a moment the vast expanse of this field, the millions of items of which some cognizance must needs be taken, and also the astonishing rate at which the store is accumulating, the task seems quite hopeless in any extended or comprehensive sense.

Leibnitz, I believe, has been indicated as the last great scientist whose mind could be said to have compassed practically the then existing store of scientific learning. Regardless of the degree of accuracy with which such a statement can be made, it is very sure that no mind of the present day can do more than hold in view the content of a very small corner of the constantly widening field of scientific activity. And as the years go by the condition becomes ever more aggravated in this respect. We are continuously adding to the scope and variety of our store, its extent both in number and diversity of character becomes daily more bewildering, and in corresponding degree the task of developing an effective science of the use of science becomes seemingly ever more and more hopeless.

Confronted with such a condition, what should be our attitude? Should we continue to do nothing and allow the content of the body of science to increase without regard to the question of its application, or should we make some attempt to improve the existing condition. Is it not worth our while to attempt at least to take the measure of the undertaking in certain limited areas of the field, or to do some little even if a comprehensive treatment lies beyond our capacity?

I believe that this is our clear duty. Because we can not do everything which an ideal treatment might indicate, it does not follow that we should not do what we may. It will mean a distinct effort along measurably new lines. It will imply assemblage, analysis, selection, synthesis in various ways, classification, coordination and the development of ways and means of detecting and setting forth what the mathematician might term systems of point correspondences between the two classes of material, scientific facts on the one side, human needs on the other. May we not anticipate that one of the triumphs of the twentieth century will be the making of some effective progress toward the establishment and development of a science of the use of science.

RACE SUICIDE IN THE UNITED STATES. II

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CAUSES OF THE LOWER BIRTH RATE IN THE CITY

One of the most obvious reasons of the lower birth rate in the city is the fact that fewer of the women of child-bearing ages are married. In the urban communities of the New England States only 53.9 per cent. of the women 15-44 years are married, widowed or divorced, while in the rural communities the percentage is 63.8 per cent. In the East North Central States the percentages are 59.2 and 63.2, respectively, while for the United States, as a whole, they are 57.8 and 64.6. Thus we see that, on the average, the proportion of the women married, widowed or divorced is about 7 per cent. less in the city than in the country. As has been shown above, however, the proportion of children to married women is much smaller in the city than in the country. Therefore, although the fact that many more women in the city do not marry or marry relatively late in life is an important cause of the low birth rate in the city, it is by no means the most important one.

The chief causes of the lower birth rate in the city may be summed up by saying that the people in the city more often voluntarily limit the size of their families than the people in the country. When we undertake to inquire into the causes of voluntary limitation of the family among city people, we find such widely different motives in operation in different classes of people that it becomes necessary to discuss the forces controlling the birth rate in each of these classes separately. I have divided the city population into four classes. The basis of the classification is the family income.⁸

(1) The poor, those with an income below \$750 per year. This class is composed chiefly of unskilled workers. (2) The comfortable, those having an income of from \$750 to \$1,500. Most skilled workmen belong to this class, also many people in clerical positions. (3) The well-to-do, those having incomes ranging from \$1,500 to \$4,000 or \$5,000. Most professional men and men in executive positions in industry and commerce belong to this class. (4) The wealthy, those with incomes of \$5,000 or over. Capitalists and those on the road to become capitalists belong to this class.

In the first class there is but little voluntary limitation of the size of the family. The two most important reasons why this is the case, are: (1) The people in this class do not know how to limit their families, (2) they do not care a great deal about limiting them, because they do not feel burden of a fairly large family as keenly as people in the higher classes.

There can be no doubt that the poor would practise voluntary limitation of their families much more than they do if they knew how. But as yet the laws forbidding the dissemination of such knowledge are quite successfully enforced against the poor. (In my judgment this is the only class of the population which the laws prevent from securing this knowledge and they bid fair to become ineffective even against them in a short time.) They have only been effective this long because this class depends largely upon free agencies for such medical attention and nursing as it secures, and because the members have no personal friends among doctors, nurses and others, who might tell them how to limit their families.

I believe, however, that even if the poor knew how to limit their families as generally as members of other classes, they would not put their knowledge into practise to the same extent. It is the customary thing among the poor to look forward to the economic aid of the child as soon as he or she can be put to work. In the sweating industries mere babies often add their pittance to the family income by "helping mother" with her work. Even where child-labor laws and school laws are well enforced, the parents can count on the aid of the children as soon as they are fourteen or fifteen years old. Not only does the child of poor parents cease to be a direct burden upon the parents very early, but there are usually several years in which it contributes more than its "keep" to the family income. Thus a family of four or five children may render the parents substantial aid for ten or fifteen years or even more. The parents very generally expect to get back the cost of the child before it strikes out for itself and they usually succeed. It may seem to many people that this attitude towards children is exceptional and is not a very important factor making for large families. I feel certain, however, that this attitude towards children is very general among poor people. The parents themselves were brought up to expect to go to work as soon as they were able and they expect the same of their children. The experience of those who have to do with the enforcement of child-labor laws shows that people in the poorer classes want their children to leave school and go to work at a very early age and that the children are quite willing to do so. This is the usual attitude

of poor people the world over. Hard conditions of life and simple forms of work make it necessary and possible for children while yet very young to help their parents and it is customary for them to do so. Old world ideas brought over by the immigrants also work in the same direction. The peasant economy of Europe has a place for the labor of the child and only too often the immigrants see no reason why the child should not go to work as young in this country as he would in the old country.

Many times the child begins to assist the parents at their work long before it is permitted to work regularly. It can do this quite easily, because both men and women do unskilled work. When the time comes that the child can leave school, it finds comparatively little difficulty in getting the same kind of a job as father or mother or a similar one. Children whose mothers work at home in the sweated trades can acquire all of the skill needed to do any of the work by the time they can leave school. When the boys are too big to work at the sweated trades they are able to go to the wharves with their fathers or do rough labor on construction work or any other of a thousand jobs which require no special preparation.

I would not imply that boys and girls in this class always do the same kind of work as their parents, but I do believe that the great majority of them do work of the same general nature. I should say that the boy whose father is a longshoreman and who himself becomes a deliveryman is staying in the same general class as his father. Similarly the boy who does the unskilled labor in a new subway is following in the steps of his father who is the janitor of a tenement. We are too apt to forget that only a small proportion of children can ever rise from the general class into which they are born.

I have many times been amazed at the utter lack of ambition among the children of unskilled laborers. But when one canvasses the situation carefully, one finds nothing in this attitude of children to cause surprise. They have been brought up to expect to go to work at an early age, their parents have never tried to instil into them the desire to better their lot. They have attended schools where no mention was ever made of occupations open to them, or if occupations of different kinds were brought to their attention, no efforts were made to inspire in them a desire to get into better occupations than those of their parents, and they have not been prepared to enter such occupations if the desire for them was implanted. In a word, everything in the life of the child of the poorer

classes tends to press it into the mode of life of its parents while almost nothing urges it to a different mode of life.

There are forces at work now, however, which seem to me to be bringing about a change in the attitude of parents in this class towards their children, and also to be breaking down the passive acceptance by children of the rôle chosen for them by their parents. More stringent child labor laws, better enforced, are making the children dependent upon their parents for a longer time and thus rendering it less economically advantageous for them to have relatively large families. Going hand in hand with the movement to prevent too early work among children is the movement for vocational guidance and occupational training. In so far as these movements arouse ambition in the children of the poorer classes and supply the training to help them realize their ambitions, we may expect to see them become less and less an economic asset to their families. As this takes place, there is not the least doubt but that the birth rate will fall.

It may well be that the effects of these movements on the birth rate in this class will not be very marked in this generation, but they will be in the next. Those who have themselves risen from the poor class will want to maintain their new standards and give their children at least as good a start as they themselves had, and those who wanted to rise, but were unable, will hope that by having only a fair-sized family they can give their children such advantages that they can rise. Thus the effects of better education and a longer period of childhood and preparation are certain to bring about a reduction of the birth rate.

It is not likely, so far as I can see, that the poorer classes will ever have as low a birth rate as the other classes. There will always be those who must do the unskilled work of the community and their children will, for the most part, take their places with the minimum of preparation allowed by law. Under such conditions the children of this class will naturally cease to be an expense to the family sooner than the children of the higher classes, and they will also be able to add something to the family income for several years before striking out for themselves. Thus in spite of greatly improved conditions children will always be more valuable economically to the poorer classes in the city than the other classes.

Another reason why I do not believe that the birth rate of the poor class will ever fall as low as that of the higher classes is that the poor class will always contain a greater proportion of improvident ne'er-do-wells than the other classes. People

who never look to the future, who make no plans for their own lives, who care little what becomes of their children, will always have large families. The motives of prudence and foresight operative in the higher classes are not operative among such people. No matter how widely the knowledge of birth control may be disseminated people who are shiftless, improvident and perhaps sub-normal will never restrict the size of their families to any appreciable degree.

Even though the poor class in the city has a rather high birth rate, it does not have a very high rate of natural increase (excess of births over deaths per 1,000 of the living population). If the rate of natural increase of the city population as a whole is about 5 or 6, then the rate of natural increase among the poor probably does not exceed 6 or 8. The reason it is not larger than this is that the death rate in the poor class is higher than that in any other class. The Children's Bureau has recently shown that infant mortality rises as the father's income becomes smaller. We also find that insurance companies charge a much higher premium on insurance sold to the poor class than to other classes. Moreover a comparison of the death rates of such cities as Boston and Indianapolis shows that the death rate of the former is considerably higher than that of the latter. The death rate of Fall River, Massachusetts, is still higher than that of Boston. It is, of course, impossible to tell what proportion of the people in these different places belongs to the poor class, but no one can reasonably doubt that it is greater in Boston and Fall River than in Indianapolis.

THE COMFORTABLE CLASS

IN the second class, voluntary limitation of the family is widely practised, though it is by no means universal. There are many people in this class who look upon their children in much the same way as those in the first class. In so far as this is the case, there is no need to dwell upon the motives at work. But there are also many influenced by motives that lead to the desire for a small family.

The skilled laborer who believes in the restriction of output and in the limitation of union membership can readily see the advantages in limiting the size of his family. If it is a good thing, from his standpoint, to control the amount of labor available for doing certain kinds of work then it is a good thing not to raise more children than he can find places for in his own trade or other trades of the same grade. A great many skilled mechanics have small families for no other reason than that

they believe this the most effective method of restricting the amount of labor and therefore of raising wages.

Many other people in this class raise small families because they hope to be able, thereby, to give their children better opportunities to rise into the higher classes. Many and many a family can be found among skilled laborers and clerical workers putting forth its utmost efforts to give at least one of the children a better start than its father had. In such cases, the child instead of becoming an economic asset at fourteen or fifteen years of age becomes an increasingly heavy economic burden in the years after he leaves the common school. Not only is the child a charge for a much longer period, but in the degree that the parents are successful in launching him upon his career in a higher class, they must expect to forego any return on their investment, for it takes so long to attain even a moderate degree of financial success in these higher classes that parents seldom live to see their children achieve it.

Of equal effect with ambition for one's children in causing restriction of the size of the family is ambition for oneself. There are many men in this class who feel that children would be a hindrance to them in attaining a higher position. There are also many women who have social ambitions or who desire to continue their work outside the home after marriage. In either case children are not wanted and voluntary limitation of the family is practised. Since, however, personal ambition is much more common in the third class than in this, I shall not discuss it further here.

The lack of training for women in home-making which is so prevalent among all classes of city women shows its effects most markedly in this class. The girls usually leave school after they have finished the grades or early in their high-school course and work for several years in factories, stores or offices before they are married. The work they do is very largely unskilled and requires little thought or close attention. In many factories they repeat a single simple process over again and again until it becomes purely mechanical. In the stores only a few ever learn more than the simple mechanical parts of salesmanship. Even in offices as stenographers and filing clerks, their work is but little less mechanical than in factories and stores. In any event the work of the girl who expects to work only until she gets married very seldom offers much opportunity for her to develop responsibility, self-reliance or foresight. Instead of preparing girls for home-makers, such work as they do induces careless habits and an indifferent attitude towards work of all kinds which is demoralizing in the extreme. These girls never

learn to regard work as the normal and proper condition of life. They do not know what it means to find work interesting and to put the best of themselves into it. They rather come to regard work as a necessary evil to be endured for a given length of time daily either because they must work to live or because they need the money to have a good time outside of working hours.

The girls are not primarily to blame that they so regard their work. The organization of our industrial system is such that most girls never get a chance to do work that is interesting to them nor do they ever have their attention called to the opportunities for self-expression in their work. It is not the least surprising, therefore, that these girls have never developed the qualities which make a successful and happy wife and mother. Such qualities as patience, economy, foresight, good taste and adaptability—essentials to a happy life under all conditions—are not to be acquired with the taking of the marriage vows; they must be developed slowly through the years. In my judgment the work of these girls not only does little to help them develop such qualities, but often actually aids in developing other traits of character which unfit them for home life, *e. g.*, carelessness, shirking, selfishness, irresponsibility and vulgarity. The woman who looks upon her daily life in the home as she looked upon her day's work in the factory or store before she was married is quite certain to find little there which will compensate her for raising a family. When this attitude towards the home exists, when all the good things of life are thought to lie outside of the daily routine of home life, family limitation will be practised if the woman knows how.

Although the birth rate in this class is considerably lower than in the first class I believe that the rate of natural increase is not much different, for the death rate is also lower. But it may well be that in recent years with the improvement of the public health agencies administering to the poor the rate of natural increase of the poor has come to exceed that of this class. Unfortunately we have no very conclusive evidence on this point.

THE WELL-TO-DO CLASS

In the third class voluntary restriction of the size of the family is almost universal. In addition, late marriages and celibacy contribute to a very low birth rate. The motives leading to late marriage and celibacy do not need much special attention because they are the same, in general, as those leading to the rearing of small families among those who are married. It

may be that the ease and comfort in which both bachelor men and women can live in the cities are motives which of themselves lead many to forego marriage, but I believe that ambition in various forms is the most potent motive leading to celibacy, as it is to family restriction.

Most professional and managerial positions offer abundant opportunities for advancement to capable, wide-awake, energetic, men and women. Honor and wealth are the rewards of diligence in these positions. The ambitious young man who goes into business hopes soon to leave the well-to-do class and join the wealthy as do many who go into the professions. There are many in the professions who do not care to leave this class, but rather who are ambitious to gain recognition through scholarly or artistic work, which is more dear to them than wealth. In either case—in seeking honor or wealth, or both—personal ambition is the dominating motive in life and has a great deal of influence upon the size of the family raised.

The young man in business who sees vistas ahead in which he may exert power through wealth has little time or inclination to give of himself to his family. He may be quite willing to meet the expenses of a relatively large family; but he is so immersed in his work that he is likely to forget to be human. He probably expects his wife to shoulder the entire burden of worry and care at home, so that he will not be distracted from his work. The wife soon becomes weary of bearing her burden alone and is ready to take measures to prevent it from becoming greater. So it is that the ambition of the father lies at the basis of family restriction in many cases.

Again the father may feel that he needs all the money he can possibly save to further his business plans and so takes means to prevent the coming of children. He often feels also that he will be hampered in his freedom of movement by even a fair-sized family. Then there is always the element of chance in business, and a man may not be willing to give hostages to fortune until he can be reasonably sure that he can redeem them. In the professions the situation is much the same, with the exception that the goal is more often recognition of some kind than mere wealth. Better than wealth to a lawyer may be the appointment to the Supreme Bench, better than wealth to a physician may be the discovery of some new means of aiding mankind, better than wealth to the engineer may be the successful completion of some public work, *e. g.*, a Panama Canal, better than wealth to the scholar may be the writing of an essay which will inspire good thoughts and noble ambitions

in his fellows. But the way to success in the professions is slow and laborious, and even a moderate-sized family may make the ascent much slower and more difficult.

There are also numerous cases in this class in which the man marries so that he may increase his acquaintance among men who may be of help to him through the social activities of his wife. Many such marriages are childless, while many more have only a single child.

It is quite likely, however, that only a small proportion of the women who spend much of their time and energy in *social life* do so with the object of furthering their husbands' interests; most of them have social ambitions of their own. The care and expense of even a single child will seriously curtail the social activities of a woman of this class and so, many times, children are sacrificed to social ambitions. Children tie a woman to the home rather closely for a good many years if she gives them a true mother's care. They are also expensive. No doubt the woman in this class very often has to make a choice between another child and some cherished object which will further her social ambitions. An automobile, a new home, new furniture or more expensive clothes will each and all enhance one's social position and keep one before the attention of one's friends, while another child will withdraw one from their attention for a considerable time and make it more difficult to appear so well in their eyes. Only too often the temptation of the easy and immediately pleasant way out overcomes them and they shirk the real duty of a woman.

Like the mistrained or untrained women of the lower classes, women of this class who "go in for" social life see no satisfaction to be derived from the daily routine of the home. The dearest objects in life lie outside the home. Nowhere among their friends and acquaintances do they encounter any disapprobation of the frivolous, meaningless lives they are leading, for they are all of a feather. If it is to women of this type that the charge of parasitism, so often heard now-a-days, refers, it is very largely justified.

Again there are many women in this class who want a "career." They want to be independent economically and socially. Some of these women do not marry, but more of them do marry, although relatively late. Of those who do marry, many regard their work essential to the highest self-respect and self-development and therefore find no place in their lives for the bearing and raising of children. Happily there is a reaction, in late years, from the extreme type of feminism prevalent about a generation ago, which taught that for a

woman to be dependent on a man for support was disgraceful and not to be tolerated by any woman of strong character.

But by no means are all the women of this class of the type that would prefer not to have children. The majority, without doubt, are women who find a satisfying existence in simple home life. But even such women do not desire large families, for they find the raising of children in the city a task of ever-increasing difficulty.

As I have watched the child life of the cities, especially among this class of people, I have often wondered that they tried to raise children at all. Children are not wanted in most apartment houses in desirable sections of the city, nor will single houses be rented to families with children if those without can be secured. Open places for play, close at hand, are generally lacking, while a private yard where one's children hold undisputed sway is almost unknown. Thus the naturally venturesome spirit of youth has no place in which to express itself in ways useful to the child and not troublesome to others. On the other hand, the opportunities to get into mischief seem to be unlimited.

Our cities to-day seem to be organized for the repression of the natural life of the child rather than to encourage its normal expression. *Don't! Don't! You must not! Get out of the way! What are you doing here!* are apparent everywhere, while, *Come on! Take part! Enjoy yourself! Here is a place for you!* are scarcely visible anywhere. Because of these conditions it is not unlikely that, in this class where standards of living are high and income not sufficient to permit of much help in the home, one child causes more work and worry than several in the lower classes.

But aside from the care and expense of raising children while they are comparatively young, parents in this class generally have to provide for their children for a much longer period than those in the lower classes. At the age the child of the poorer classes begins to be self-supporting the child in this class begins to make greater demands upon the economic resources of its parents. Prevision and foresight are well developed in these people and consequently they make definite plans, so that their resources will meet their own needs and provide a good start in life for their children. Expenses during high school, college, technical school and possibly even for a year or two while getting a foothold in some profession, generally strain the family resources to the limit when the family is small. Therefore a large family is not desired.

The desire for travel is another motive often leading to the restriction of the size of the family in this class. It needs no

argument to show that children make travel more difficult both from the standpoint of expense and from that of leisure. Each child born increases the normal expenses of the family and makes it more difficult for the parents to take their children with them or to leave them behind when they travel. Thus with the growth of the family the likelihood of being able to travel decreases. Therefore, where there is a strong desire to travel, a "trip" very often is chosen as the alternative to another child.

The desire to attain culture is also a motive leading to family restriction in many cases. A certain amount of leisure and freedom from harassing care are necessary to the development of a cultured personality. A large family of children or even a moderate-sized family is apt to make the work and the worry of maintaining class standards so difficult that one will have little energy or inclination for anything beyond the daily routine. The realization that this is likely to take place causes many people to raise only one or two children. They feel that the sacrifice of self-development involved in rearing more is too great.

We have no very extensive data bearing on the birth rate and death rate in this class, but such data as we have seem to justify the conclusion that there is no natural increase. My own belief is that this class does not produce enough children to keep up its numbers, but we must await further investigations before we can be certain on this point.

THE WEALTHY CLASS

There is no sharp line dividing the fourth class from the third either in regard to the motives leading to family restriction or the rate of natural increase. Family limitation is almost universal in the fourth class and ambition in one form or another is the most powerful motive leading to it.

This class is quite small, comprising not more than two or three hundred thousand families (judging from the federal income tax returns). The great majority of the men belonging to it are men having incomes near the lower limit. Most of these men hope very soon to increase their incomes and are struggling desperately to rise. Nowhere in our population is the competition more strenuous than between men who have attained some measure of success and whose appetite for it is therefore insatiable. These men are "climbers" in their lines and very often their wives are social "climbers." Thus the chief interests of both husband and wife lie outside the home and children are regarded as a burden. Such people have no real home life and do not care enough for it to stop scrambling

for position. The husband only too often thinks of his wife as the means to a larger acquaintance among people who may be able to help him along and the wife regards the husband and home merely as necessary incidents to respectability. The result is that their families almost never comprise more than two children and very often none at all.

These "climbers" have neither accumulated wealth nor do they have very assured positions in society. They have therefore nothing definite to bequeath to their children. They have no pride of family urging them to leave descendants to carry on the family name and traditions; they have no definite position in the community, which they can be assured of transmitting to their children. These people are themselves adrift, they know not whither they are bound, and many of them feel, in their more serious moments, that life is so uncertain and there is so little worth while to be got out of it that they will save trouble all around if they have no children.

On the other hand, among the wealthy, whose position is assured, there is a certain amount of pride in one's family, leading them to rear children to carry on the family name and fortune. They have not only wealth but a much-coveted position in the community which they can command for their descendants. This portion of the wealthy class probably more nearly reproduces itself than the "climbing" portion.

Undoubtedly the sheltered lives of ease and luxury led by many girls in the wealthy class and even by some in the well-to-do class disincline them to undergo the hardships of bearing and rearing a family. To a girl who has been brought up in the belief that her own whims and desires are of prime importance and that all values are to be judged by these pampered inclinations it is often inconceivable that she should deliberately do any thing to bring herself pain and work and worry and probably even deprivation of some customary luxuries. Such girls brought up apart from the stern realities of life are not capable of judging values aright. They know little of the feelings and values which grow up naturally when men and women struggle side by side, help to bear one another's burdens, share sorrows as well as joys and, above all, live close to the great streams of simple, work-a-day humanity. Women whose only passion is for ease and luxury lose touch with humanity and substitute for true human values those of a small and highly institutionalized class.

It is especially unfortunate that the women of this class do not rear moderate-sized families, because they are so widely imitated by the women in other classes.

(To be continued)

THE PHYSIQUE OF THE ANCIENT HAWAIIANS

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THE primitive Hawaiian type is rapidly vanishing. Like many of the island peoples of the Pacific, contact with the white race has wrought far more woe than weal. The Caucasian vices were acquired with much greater facility than were the sober virtues, and a variety of influences, racial and sociologic, have led to the decimation of what was at one time one of the finest peoples in the Pacific Ocean.

It is not the purpose of this paper to delineate the successive stages in the extinction of the ancient Hawaiian, nor to analyze the complex factors that have so rapidly undermined the race, but rather to present a somewhat detailed sketch of the bodily characteristics of the typical native in the prime of his "golden age." The pathetically rapid shrinkage of the native population may be visualized from the following data. Captain Cook's estimate in 1778, which may have been somewhat, although not greatly, exaggerated, was 400,000. Five decades later, in 1823, the census showed only 142,000. At the close of another decade the native population dropped to 130,000, a shrinkage of 12,000, or at the rate of 100 decrease per month. The next interval of thirty-six years witnessed a frightful decrease of two thirds of the total population, reducing the natives to 44,000. In 1900 there were but 30,000; the past ten years have brought a decrease of over 10,000, and to-day, in 1916, there are probably not 16,000 pure-blooded Hawaiians.

The modern tourist who visits the Hawaiian Islands sees very few of the pure-blooded natives; those in Honolulu, the capital city, are very largely "part-Hawaiians" or hybrids, and a very considerable percentage of the natives residing in outlying districts have foreign blood. The official statement of population as given in the last report of the Governor of Hawaii (1915), records—in round numbers—26,000 native Hawaiians for 1910 and 24,000 for 1915, a decrease of 2,000, or over 7 per cent. in five years. The mongrel or part-Hawaiian population is given as 12,500 for 1910, and 14,800 for 1915, an increase of 2,200, or 18 per cent. for 5 years. It should be emphasized that

a large portion, perhaps thirty per cent., of the natives listed in the above figures as "native Hawaiians" are not in fact, pure-blooded Polynesians, but have varying proportions of mixed blood. The natives have intermarried freely, both in and out of wedlock, with all who came to their shores, since the days of the first explorers, so that to-day it is practically impossible to absolutely determine pure lines of descent.

In striking contrast with the degenerate mixtures that characterize the modern native stand the records of the first explorers as to the splendid and beautiful physique of the primitive Hawaiian. Captain Cook, the first English discoverer of the islands, describes the chief Kane-ena as "one of the finest men I ever saw. He was about six feet high, had regular and expressive features, with lively dark eyes; his carriage was easy, firm, and graceful." Bryan, in his "Natural History of Hawaii," states:

At the time of the discovery of the Hawaiians they were physically one of the most striking native races in the world . . . as a race they were tall, shapely, and muscular, with good features and kind eyes. In symmetry of form the women have scarcely been surpassed, if equalled, while the men excelled in muscular strength.

Anthropologists agree that the ancient Hawaiian was one of the finest physical types in the Pacific, and compared very favorably with the best types from any other part of the world. They were tall and well developed, with splendidly shaped torsos, and fine muscular limbs of excellent proportions. According to measurements compiled by Topinard, the Hawaiians have greater manual strength than the Micronesians, Australians, Negroes, Iroquois, Chinese, French seamen, or American soldiers, and are only surpassed by the Iroquois in strength of back. The average height was about five feet ten inches, and many of the chiefs were over six feet. A skeleton from one of the ancient burial caves measured six feet seven and three quarters inches, and, as Bryan states, "there is sufficient evidence to establish the fact that men of even larger stature were by no means unusual."

The physique of the chiefs and their families was so superior to that of the common people that some anthropologists have thought them to be of a different tribe or race. The difference is not to be accounted for in this way, however, but rather to the excellent care taken of the children of the nobility, their better food and other conditions of life, and their healthful sports and exercises. The drudgery was done by the common

people and slaves; the chiefs devoted themselves to the development of bodily and mental superiority. Captain King (1778) states:

Those [chiefs] whom we saw here were, without exception, perfectly well formed; whereas the lower sort, besides their general inferiority, are subject to all the variety of make and figure that is seen in the populace of other countries. They seem to have very few native diseases among them, but many of the chiefs suffer dreadfully from the immoderate use of the awa.

The physical superiority of the chiefs is striking negative evidence against the popular belief in the bad effects of inbreeding. The chieftain class married habitually within itself, very commonly within the same family. Frequently a chief married his own sister, in order that the offspring might have the highest rank. These very close intermarriages were a permanent policy of the Hawaiian nobility during a period of at least many hundred years. There is absolutely no evidence of deterioration of any sort. On the contrary, all who saw the chiefly classes in the early days agree as to their striking bodily and mental superiority.

The color of the Hawaiian was an olive-brown or rich brown, never black nor conspicuously reddish. The common people, who were constantly engaged in fishing, field labor, and the like, were usually darker, through exposure to the weather, than the chiefs and women of rank, who avoided the sun. The variation in hue was considerable, ranging from a light coffee brown to a dark reddish-brown. Occasionally there was a distinct olive tint. After intermingling with Europeans this range of color was, of course, greatly accentuated with the varying degrees of hybridism.

The skin of the healthy, well-kept primitive Hawaiian was by no means unattractive. Coupled with their superb physique it gave them the appearance of "burnished statues" or "bronze Greek gods." It is a matter of common observation among travelers that in the dark-skinned peoples the nude figure does not give the impression of lack of clothing—there is absent that glaring contrast which the white body exhibits when disrobed. When the Hawaiians saw white men for the first time, they thought that the latter were suffering from some serious skin disease.

In the ancient régime the better class of natives kept their skins in excellent condition, through daily baths in the sea and in fresh water, and by oiling the body with coconut oil. The

cheeks of the young men and maidens were rosy, and the skin gave every evidence of abounding vitality.

The chiefs and women of rank kept their skin and bodies in perfect condition through an elaborate system of *lomi-lomi* or massage. The body was stretched at full length on the mats, and the operator (sometimes there were several operators) gave an exceedingly thorough and vigorous massage, not only rubbing, but also kneading, pressing, thumping, pulling, and using a number of other motions peculiar to the art. The noble person receiving the massage would commonly sleep during this highly beneficial performance, which often lasted for several hours.

Many of the chiefs and women of their families have been remarkable, not only for their height, but also for their weight. Four hundred pounds was formerly not unusual for one of this favored class, and three hundred pounds was a prevalent weight among the nobility. This corpulence was much more common among the women than the men, and was due to a variety of factors: (1) A diet consisting very largely of excessively starchy foods, such as *poi*, bananas, sweet potatoes, breadfruit, etc. Meat, chiefly in the form of fish and other marine animals, was a distinctly minor item in the diet. (2) Habitual over-eating. The Hawaiian nobility, like those of medieval European stocks, were often gross feeders. Incredible quantities of food would be consumed at a single meal. Gluttony was the prerogative of aristocracy, very much as was intoxication. (3) An indolent mode of life. As in other aristocracies, all the menial and productive labor was performed by the lower classes; the upper stratum was provided with abundant leisure, which was commonly abused. (4) For the women, obesity was a part of the ideal of feminine beauty, and was cultivated to a gross and grotesque degree.

A distinctive character of the ancient Hawaiian, and of the Polynesian peoples generally, was the ease and grace with which the limbs were habitually moved. The gait of the men and women alike was almost invariably graceful, smooth and dignified. The stately deportment of the chiefs and priests is noted by all the early explorers. The Polynesian mode of walking lacked all of those nervous, jerky motions that are so characteristic of many European peoples. The beautiful muscular development, and the absence of nervous temperament, were alike manifested in the tranquil poise and unhurried gait of the primitive Hawaiian.

In the movements of the arms a similar grace and control

was distinctive. The gestures of the orator or chief were smooth, sweeping, and as impressive and finished as those of a cultivated white man. In the dances the arms played a very important part—many of the “dances” were performed by large numbers of persons *seated*—and were moved with beautiful rhythm. In those dances in which a large company participated the movements of each individual were coordinated with extraordinarily precise harmony with those of the others, a rhythmic precision far more accurate than that, for example, of the modern Occidental ballét.

Tatuing has become wholly extinct. The art itself is forgotten, and there are now no tatued natives, nor have there been for many years. The Hawaiian never developed systems and patterns of tatu as elaborate as those of his South Sea Island congeners, the Samoans and the Maoris. It is entirely probable that the primitive Polynesians who were the first discoverers of the Hawaiian Islands, and the progenitors of the Hawaiian people, left the South Pacific dispersal center, Samoa, before the art of tatuing had evolved to its final, highly elaborate designs. However that may be, the Hawaiians at the time of the discovery by Europeans, were very sparingly tatued. Tatuing appears to have been more prevalent on Kauai than on the other islands of the group. It should be noted that the Kauaians were distinguished from the natives of the other islands by a number of archaic traits and customs.

The Hawaiians had neither the complicated thigh- and hip-tatuing of the Samoan, nor the ferocious facial tatuing of the Maori. The art was confined largely to the males, and so far as the records show, was a prerogative of rank. Unlike the Maori and Samoan women, the Hawaiian females do not appear to have used the tatu, save for a curious custom which Captain King records as follows:

The custom of tattooing the body they [the natives] have in common with the rest of the natives of the South Sea islands, but it is only at New Zealand and the Sandwich Islands that they tattoo the face. They have a singular custom amongst them, the meaning of which we could never learn—that of tattooing the tip of the tongue of the females.¹

Upon contact with Europeans the natives abandoned their own modes of tatuing, and thus the records are very scanty. The available evidence, however, indicates that the patterns were much coarser and inartistic than those of the Samoans. In many instances the markings were limited to a few spots on

¹ The women also sometimes had the back of the hand marked with a pattern somewhat similar to that of an open-work glove.

face, near the eyes or mouth. One famous chief, Ka-hekili, had one side of his body, from head to foot, tatued, so that he appeared half brown and half black, a pattern like a jester's costume.²

There are no records indicating special symbolic significance to the patterns, like those of the Bornean head-hunters. The lowest class in the Hawaiian social system—the slaves or *kauwa*—usually captives of war, were marked or branded on the forehead, but this seems to have been distinct from the tatu, and was regarded as a sign of infamy or disgrace. The opprobrious epithets, *lae-puni* and *maka-wela*, which were applied to the slaves, have reference to the brand or mark.

The Hawaiian head was well formed, and closely resembled that of the best European types in contour and proportions. It rarely exhibited the deformities which characterize the skulls of many primitive peoples. The skull was sub-brachycephalic or "mesaticephalic" in type. The cephalic indices of a large number of living "specimens" averaged 82.6. Those of an extensive series of skulls average 79.0, with a minimum of 75.0. This range is similar to that found among the Chinese people. The Hawaiian skull was never prognathous. Broca found among the Hawaiians the highest orbital index that he had ever observed. The jaws were of good proportions, resembling those of European types, with well-formed chin and cheeks. Projecting or noticeably receding jaws were rare.

The hair was black or dark brown. It was straight, slightly wavy, or curly; never frizzy or kinky like that of the negro or Papuan, nor lank like that of the Malayan. It was strong, and usually of rather coarse texture; very fine texture was rare. Old age brought gray or white hair; baldness was very exceptional. The hair of the women was long, but no unusual lengths are recorded. There is no evidence to show that very long hair was looked upon as a special attribute of feminine beauty. Alexander states that "it was the fashion among the women to wear the hair short in front and on the sides of the head, and to turn up the edges on the forehead and temples with a wash made of lime or white clay." The custom of heavily liming the hair was not practised in the Hawaiian Islands as commonly as in the South Pacific. The hair of the men was cut in a variety of peculiar styles, sometimes with a mane-like crest over the center of the crown, sometimes with long locks reaching down toward the shoulders. The beard of the men was thin and

² Tatuing was sometimes done as a token of mourning at the death of a friend or chief.

sparse, and restricted chiefly to the chin and lips. In many instances it was plucked out, as was the hair on the legs and arms. The typical native man was smooth, and the chest was usually lacking in the hairy growth characteristic of many Europeans. Captain King states:

The same variety in the manner of wearing the hair is also observable here as among the other islanders of the South Seas; besides which they have a fashion, as far as we know, peculiar to themselves. They cut it close on each side of the head down to the ears.

The face was moderately broad, with a kindly, open countenance, and features quite regular and often beautiful. The young people of both sexes were, with few exceptions, good looking, and the girls were often of striking and voluptuous beauty. Captain King writes:

Many of both sexes had fine open countenances, and the women in particular had good eyes and teeth, and a sweetness and sensibility of look, which rendered them very engaging.

Bryan states:

In general, their features were strong, good humored, and in many instances, when combined with their splendid physiques, produced a striking and impressive personality that gave the impression of their belonging to a very superior race.

The profile was regular, not prominent, and usually pleasing. In many instances it closely resembled the profiles of the higher Caucasian types.

The nose was of good length, well shaped and arched. Frequently it was somewhat flattened, due to artificial pressure and massage in infancy, as a flattened nose was esteemed much more highly than a pointed or protruding one. The practice of massaging the newly-born babes, especially those of the nobility, was general and elaborate, and was supposed to greatly influence the future beauty of the child. For example, the outer angles of the elbows, particularly of the girls, were vigorously massaged, as a sharply pointed or angular elbow was looked upon as a very ugly characteristic.

The eyes were large, well formed, and expressive. Until European mixtures were introduced they were invariably black. Occasionally the eyes were a trifle oblique, but this character was comparatively rare, and apparently of no anthropologic significance. The lashes and eyebrows were black, well-formed, and often quite long. Many of the younger women had beau-

tiful eyes. As indicators of character the Hawaiian's eyes were typically kind, cheerful, mild and generous. The crafty, cruel, bloodthirsty, and lustful types occurred, of course, as they do in any human society, but under ordinary conditions they were distinctly in the minority, and did not represent the normal Hawaiian life. The eyes of the ancient Hawaiian chief of good character were as fine and expressive as those of a high-grade European. Those of many of the women were notably bright, clear, and attractive. The ability of the primitive Hawaiian as a sailor and a woodsman indicates that the power of vision was well developed, although not to any remarkable degree. There is no indication that he possessed the keenness of vision customarily ascribed to such peoples as the American Indian and the Australian aborigine.

The Hawaiian mouth was well formed. The lips were usually of medium thickness, frequently voluptuously thick and everted; rarely thin. The upper lip was usually a trifle shorter than the lower, giving to the mouth a peculiar, not unpleasant, and easily recognizable, racial form. The thick lips, particularly of the younger women, were well molded and attractive. Like the eyes, the mouth was typically indicative of kindness, mildness, and generosity. The tight, pursed, narrow mouth was very rare.

The teeth were excellent in shape and arrangement, and of a glistening pearly whiteness. The beautiful teeth of both the men and the women are frequently mentioned by the early explorers. The beauty was often defaced by a curious custom of knocking out one or more of the front teeth as a token of grief upon the death of some friend or chief; in many instances the middle-aged and older people would lack many of the front teeth, both upper and lower, as a result of this senseless custom.

It is not the purpose of this paper to exaggerate the physical excellences of the primitive Hawaiian, nor to give the impression that splendid manly physique and sensuous feminine beauty were universal. As in all human communities, Hawaii also had the ugly, the maimed, the dwarfed, the diseased, the weaklings. Many of the older women were veritable hags; many of the older men were disfigured by dissipation or by drudgery. Captain Cook described a chief named Koa, who "was a priest, and had been in his youth a distinguished warrior. He was a little old man, of an emaciated figure; his eyes exceedingly sore and red, and his body covered with a white leprous scurf, the effects of an immoderate use of the awa." In general, however, the people seemed to be remarkably free from disease or bodily disfigure-

ment; it was not until the vile venereal diseases of the white sailors and traders began to spread among the people, that deterioration set in. These and other Caucasian diseases, the inordinate use of the liquors plentifully supplied by the white man, and a variety of other debasing influences undermined the constitution of the people with astonishing speed; thus the primitive Hawaiian, with fine physical and mental traits of the greatest promise, is disappearing, and in a few years will have vanished forever.

RILLY, A FOSSIL LAKE

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THE science of paleontology may be as dry as dust or as interesting as a masterpiece of fiction according to the degree to which its devotees grasp its principles and ideals. All are doubtless inspired by the wish to contribute toward the completion of the geologic record and to elucidate the phylogenies of the animal and plant kingdoms. This most exact and painstaking work undoubtedly forms both the foundation and superstructure of the paleontological temple of science, but, until it becomes open to the devotees of the other earth sciences and to the general public, inspiration and achievement are limited to a small circle of the elect and the temple remains without liturgy or ceremonial.

Fossil floras and faunas are not interesting chiefly as medals of creation, but as the objective evidence of the marvelous living and moving life of the sea, earth and air of bygone days. They record the dynamic and epic history of the struggle for existence during countless ages and furnish the data for what Huxley aptly termed retrospective prophecy—the restoration of the past. We desire to know the progressive changes in the continental outlines; when the invasions of the land by the sea occurred; the kinds of life and how they lived; the depths and temperatures of the waters—whether clear or muddy, brackish or fresh; whether the aquatic forms were inhabitants of lakes, streams, lagoons or seas; whether the land animals and plants were those of forested glades, stream banks, plains or sea shores.

Such questions we ask of fossil floras and faunas and while the reliability of the answers depends upon our exact knowledge of both recent and fossil forms of life and their environments, systematic paleontology is only the means toward these ends.

Some sixty miles directly east of Paris on the western border of the Champagne country—the Campi Catalaunici of the ancients—lies the little town of Sézanne, long celebrated in the annals of paleobotany for the marvelous preservation of lower Eocene plants in travertines. These exposures of traver-

tine, notably La Butte-aux-Grottes southwest of the village, early excited the interest of geologists and we find the deposits described¹ as early as 1842. The travertine is of various kinds—sometimes massive, sometimes irregularly laminated and elsewhere porous and full of minute galleries. Langeron² and others have shown that while the more massive deposits may be formed by evaporating waters, the most active agents in its formation were colonies of minute freshwater algæ of the families Nostocaceæ, Oscillatoriaceæ and Chlorophyceæ. The metabolism of these algal colonies caused the soluble bicarbonate of calcium to lose its second molecule of carbonic acid, the insoluble neutral carbonate being thus thrown down from solution and deposited. The travertine thus deposited in the interstices of these algal colonies has a porous structure and the abundance of the larvæ of various dipterous insects in such algal mats readily explains the tiny galleries that traverse the travertine and thus lead us to the conclusion that various midges and gnats danced in the sunshine of the Sézanne woods.

Fossil plants were described³ from these travertines as early as 1842 and Brongniart⁴ enumerated a *Marchantites* and two ferns from this locality. Watelet⁵ added an alder, a beech and one or two other species in 1866, but it remained for Saporta⁶ to do full justice to the richness of this deposit, his results appearing in 1868. The late Munier-Chalmas, with characteristic painstaking efforts, devoted much time to making wax casts of the flowers, fruits, seeds and insects preserved at Sézanne and his wonderful collection is now at the Sorbonne. So far as I know he published no descriptions of these objects and except for a fine paper on the flowers, fruits and seeds of *Sezannella*, a genus of Sterculiaceæ, by Viguier⁷ in 1908, they remain undescribed. Langeron⁸ has published several short papers on the mode of origin of the travertine and on additional

¹ Duval and Meillet, "Coupe des terrains des environs de Sézanne," *Bull. Soc. géol. France*, 1 ser., tome 14, pp. 100–104, 1842.

² Langeron, M., *Soc. Hist. Nat. d'Autun*, 1899.

³ DeWegmann, *Bul. Soc. géol. Fr.*, 1 ser., tome 14, pp. 70–71, 1842.

⁴ Brongniart, A., "Tableau," p. 115, 1849.

⁵ Watelet, Ad., "Description des plantes fossiles du bassin de Paris," 1866.

⁶ Saporta, Gaston de, *Mém. Soc. géol. France*, 2d ser., tome 8, pp. 289–436, pl. 22–36, 1868.

⁷ Viguier, R., *Revue gén. Botanique*, tome 20, pp. 6–13, Figs. 1–6, pl. 5, 1908.

⁸ Langeron, M., *Bull. Soc. Hist. Nat. Autun*, tome 12, pp. 431–455, 1899; tome 13, pp. 333–370, 1900. *Bull. Mus. d'Hist. Nat.*, Paris, tome 5, pp. 104–106, 1899: *Idem.*, tome 6, pp. 318–320, 1900.

forms of plants, so that the described flora now numbers about 100 species and many more await description.

Sézanne lies near the western limit of the Champagne country, where the somewhat monotonous vineyard clad chalk plain disappears beneath the escarpment of the Tertiary plateau of the Ile de France. It is situated in the Department of the Marne which belongs in part to the Archbishopric of Reims, founded in the third century, and partly to the See of Châlons. Reims, the capital city of the Remi and where the kings of France were crowned, is only about 40 miles to the northward. About 30 miles northeast of Sézanne is Châlons, near which 1,466 years ago (A.D. 451) Attila, the most powerful heathen king that ever ruled in Europe gathered together the Huns of the fifth century after reverses on the Loire and was finally defeated by the soldiers of Aëtius and his Gothic allies in what was the last great victory of Imperial Rome and the first great battle of the Marne. The second great battle of the Marne is fresh in our memories and in its decisive results and in the character and ambitions of the contestants it is in many ways comparable to the battle of Châlons.

A small tributary of the Aube rising in the hills that mark the escarpment of the Tertiary plateau and the chalk plain of the Champagne flows to the southeastward by Sézanne.

During the Upper Cretaceous a shallow sea of Atlantic origin invaded the Paris Basin. The prevailing sediments of this sea were earthy limestones commonly known as chalk, and this Upper Cretaceous chalk now outcrops in a broad ring or aureole around Paris, its inner margin lying from 30 to 100 miles distant. The chalk underlies all the later deposits in the center of the Basin. Its characteristic weathering results in the formation of a more or less treeless plains type of country, such as the plains of the Champagne on the east, of Picardy on the north, of upper Normandy, Maine and Touraine on the northwest and west. This chalk country extends from Bourges northeastward past Troyes and Châlons. At Reims it swings to the west past Vervins. At St. Quentin it turns again to the south past Amiens, Beauvais, Rouen, Chartres, Blois and Tours to Châteauroux. This is a country of ancient as well as modern greatness and the very names carry us back through eventful human history to the days of Cæsar's campaigns. The relics found in the valleys of the Somme and the Seine carry us back still farther to the men of the old stone age, some 10,000 years before Cæsar's time, and the fossil shells that we dig out of the chalk and that represent the inhabitants of this Upper Creta-

ceous sea carry us back some three or four millions of years earlier to a time when man was not even a promise and the dinosaurs were the lords of creation. During its maximum extent this Upper Cretaceous sea covered most of France—the only emerged areas being the massifs of the Ardennes, Bretagne, Cantal and Savoie. The Paris Basin was connected with the Mediterranean along the Rhone valley and with the Bay of Biscay across the lower valley of the Loire. Europe was an archipelago at this time, the Scandinavian and Russian shields being the only large and continuous land masses. This Cretaceous sea eventually commenced to shrink and by slow stages nearly all of the Paris Basin emerged from beneath its waters. Not to dwell upon the events of the closing days of the Cretaceous, which is foreign to my present purpose, it may be noted that while the shallow epicontinental seas lingered longer in some regions than in others, as, for example, in Denmark and North Germany, this was a time of littoral and continental deposits.

The length of time during which the land was emerged varies for different localities, and while we have no measure of this interval it must have been very long, judging by the changes in the life that we observe in the earliest Eocene seas. The Cretaceous seas swarmed with specialized cephalopods known as ammonites. Thousands of species are known and not one survives in Eocene times. The changes in the other forms of marine life, while not so spectacular, are equally marked. For example, in the earliest Eocene sea of southeastern North America, known as the Midway sea, we find an entirely different fauna from that found in the Cretaceous beds lying immediately beneath these Eocene deposits. This change in the life of successive deposits in this region is greater than has taken place in all the time that has elapsed between the Midway and the present. Equally great changes mark the earliest Eocene terrestrial faunas and floras. For example, about 350 species of plants are known from the lower Eocene of southeastern North America and not one of these plants has been found in the Upper Cretaceous anywhere. We are in an apparently new world in Eocene times and, if these changes in the life are an accurate measure of the time involved, it would seem that the seas were absent from the present land surface several millions of years and that the continental outline of Europe during this interval foreshadowed its modern outline.

The earliest Eocene sea in the Franco-Belgian Basin is named the Montian sea from deposits of this age around Mons

in Belgium. The Montian sea was limited in its extent and fell far short of reaching south as far as Sézanne. The first well-known Eocene sea in this region whose sediments are mapable over wide areas is named the Thanetian sea (from the Isle of Thanet in the London Basin) or Landenian sea (from Landen east of Bruxelles in Belgium). Between Sézanne and Reims a considerable area is occupied by the marls and limestones of Rilly, named from a little town of that name south of Reims. These are freshwater limestones and marls that were deposited in a large lake or series of ponds, as is indicated by the variety and numbers of shells of pond snails found fossil in these deposits. Nearly fifty different kinds are known and these include some land snails. Some of the genera are *Physa*, *Valvata*, *Planorbis*, *Succinea*, *Pupa*, *Helix*, etc., and they are said to resemble modern forms of the Antilles and South America. In the lakes and rivers were fish of various kinds including the curious mud-fishes (*Amia*) and swarms of gar pikes (*Lepidosteus*), both now confined to North America. Turtles of several varieties (*Chelonia*, *Trionyx*, *Emys*) were abundant and salamanders have also been found. Crocodiles basked on the banks or hunted in the waters and these included both the Nile type of crocodile and the long-snouted Ganges type or gavial.

The shores were densely wooded with broad-leafed warm-temperature types of trees, and for these the travertines found at the little butte southwest of Sézanne will give us the best picture of the contemporaneous plant life, although a similar glade flora is found near Louvois, in the sandstone of Vervin and in the marls (Heersian) of Gelinden on the road to Liège.

At Sézanne we can almost reconstruct the whole picture. A swift-flowing stream, as shown by its pebbly bed, cascaded from a low chalk escarpment into a damp wooded ravine which opened into the Rilly lake. Mosses (*Fontinalis*) and stoneworts (*Chara*) sheltered the crayfish (*Astacus*). Moisture-loving plants like the two *Marchantites*, and a variety of ferns (*Asplenium*, *Blechnum*, *Adiantum*, etc.) covered the stream banks which were overhung by figs and laurels, magnolias, walnuts, maples and a host of tree types since become extinct or no longer found in Europe. Insects and even such delicate objects as flowers are faithfully preserved in the travertine. Among the most interesting of these are those named *Sezannella* by Viguier and shown in the accompanying illustration (Fig. 1). They belong to the tribe Lasiopetalæ of the tropical family Sterculiaceæ and are related to existing

forms of the American tropics. The illustration shows a flower with two of the petaloid sepals removed, disclosing the large central superior ovary surrounded by the closely appressed stamens opening at the tips of the anthers and each opposite a reduced scale representing the vestigial petals. The second figure shows the five-valved tardily dehiscent capsule or fruit of *Sezannella*, also found abundantly in the travertine. Both are shown natural size.

Altogether twelve species of ferns have been found at Sézanne, and these include several of the tree fern genera *Alsophila* and *Cyatheites*, eloquent witnesses of the humid climate. There are two palm-like forms referred to the genus *Ludoviopsis* from their resemblance to the curious genus *Ludovia* of the tropical South American Cyclanthaceæ. An entirely extinct genus is *Dryophyllum* with four species in the

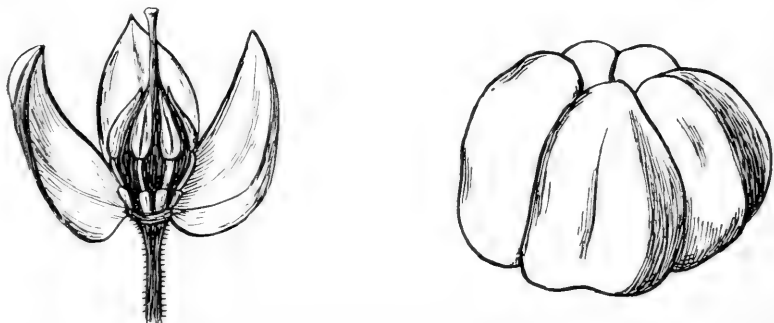


FIG. 1. RESTORATION OF FLOWER OF SEZANNELLA, WITH TWO OF THE SEPALS REMOVED, AND OF A FRUIT (NATURAL SIZE).

Sézanne woods. *Dryophyllum* was very common along the borders of the lower Eocene sea both in Europe and America, and is considered to represent the ancestral stock from which both the oaks and the chestnuts were derived. Ten different species of laurel have been found at Sézanne and these include a sassafras. The latter was a varied and common type throughout the Northern Hemisphere during Tertiary times, but is now confined to North America, where its single species is one of the very few plants of the great family of laurels (Lauraceæ) that has survived at any great distance from the equatorial region.

The Sézanne flora contained seven aralias, which are mostly American tropical types in modern floras, although common throughout the Holarctic region during the Upper Cretaceous and earlier Tertiary. *Magnolia* is another Sézanne type that is no longer found in Europe, but is now confined to southeastern

North America and southeastern Asia. There were six species of *Grewiopsis* at Sézanne which Count Saporta compared with existing Brazilian species of *Luhca*. Some of the more familiar Sézanne types were bayberries or swamp myrtle, alders, birches, elms, cottonwoods, maples, willows, sheep berries, buckthorn and cornel. There were two species of *Zizyphus*, a genus which in the existing flora comprises about two score scrambling shrubs or small trees mostly confined to the Indo-malayan tropics, but with a few species in all tropical countries. In the past *Zizyphus* was cosmopolitan, with very many now extinct species. Some distance north of Sézanne are found white seashore sands (*sables blancs siliceux de Rilly*) with the remains of marine molluscs. These are overlain by the *gravier marin de Cernay*. A few of the land animals that roamed in the Sézanne woods have been discovered around Reims in the latter beds and constitute the so-called Cernaysian fauna of the late Victor Lemoine—the oldest known European Eocene vertebrate fauna. The *gravier marin de Cernay* (Cernay is a little town about three miles east of Reims on the western slopes of the Mont-de-Berru) are seashore and river channel gravels containing sharks' teeth and molluscan shells of mixed marine and estuary forms. Scattered bones represent the land animals that were accidentally drowned or whose dead carcasses were swept down the streams into the estuaries and coastal lagoons. These give us a welcome glimpse of the terrestrial animal life of these early times. They comprise small insectivores, lemur like forms, small gnawing marsupials, numerous primitive carnivores and a few primitive hoofed animals—an assemblage much like that found in the Puerco beds of New Mexico and of similar age. Without dwelling at length on this point, enough has been said to suggest that in these earliest Eocene times the plants and animals of the whole Northern Hemisphere or Holarctic region were much alike and were able to migrate freely from Europe and Asia to and from North America. That Holarctica was a single botanical and zoological province during the early Eocene has long been the conclusion of paleobotanists and vertebrate paleontologists. This does not mean that either the floras or faunas were monotonously uniform throughout this vast region. Some of the types of plants and animals became cosmopolitan, others never did. There were always local assemblages of forest, shore and plains forms. The warm glade floras and faunas of the south as at Sézanne or in the strand flora along the expanded Gulf of Mexico were markedly different from the contemporaneous

plains floras and faunas of more arid regions such as was so much of the western United States during the Eocene.

The succession of events along the shores of the expanding and subsequently shrinking Thanetian sea are clearly indicated in the shifting sediments and their contained fossils. This history is too complex in its details for popular presentation. At one point we recognize seashore sands; at another estuary muds, forming lenses of clay; channel or delta sands and grav-

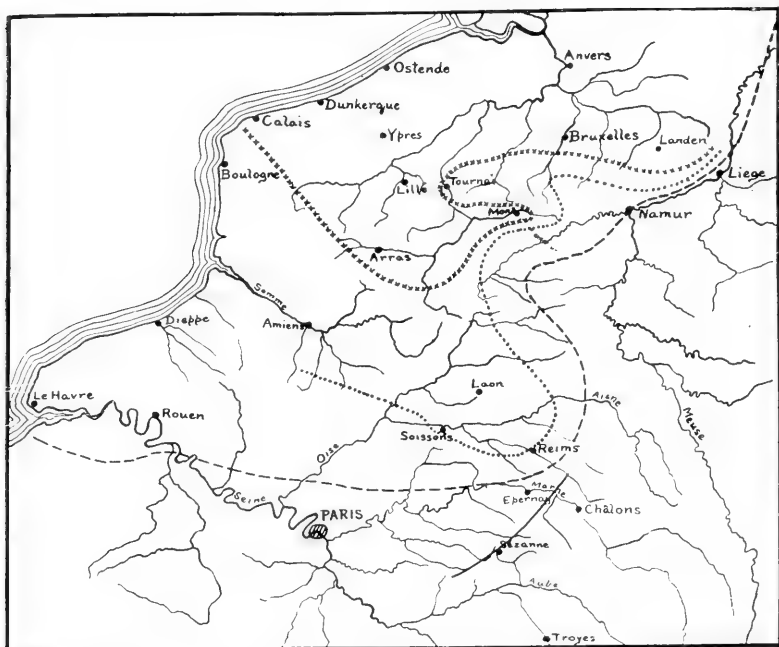


FIG. 2. SKETCH MAP OF A PART OF FRANCO-BELGIAN BASIN SHOWING PROGRESSIVE SUBMERGENCE OF THE LOWER EOCENE.

- × × × × Landward limit of distribution of *Cyprina morrisi* of the early Thanetian sea.
- Landward limit of distribution of *Pholadomya konicki* of the middle Thanetian sea.
- Landward limit of distribution of *Cyprina scutellaria* of the later Thanetian sea.
- Landward limit of the lagoons of the Thanetian sea during its maximum extent.

els occur in places; elsewhere we recognize that we are dealing with beach shingle; lenticular clay beds are seen to represent mud deposits in coastal lagoons; and dune sands are recognizable, as, for example, the *sables d'Ostricourt*, now outcropping from Bethune southeastward to Vervins, and largely made up of fossil sand dunes that followed the retreating strand line, and which contain in places the traces of vegetation appro-

priate to such an environment, as at Artres, Proix and Lewarde.⁹

The accompanying sketch map (Fig. 2), based very largely upon the excellent studies of M. Leriche, illustrates the varying history of the Thanetian sea. The Rilly lake or lakes occupied approximately the area of the rough triangle formed by Sézanne, Châlons and Reims. It is not possible to indicate its outline since its deposits merge in the seashore sands and overlying marine beds that subsequently transgressed it from the north. The sinuous line of small crosses extending from South of Landen and Bruxelles through Tournai and near Mons, Arras and Calais marks the landward limit of distribution of *Cyprina morrissi*, a characteristic mollusc commonly found in the sands of the earliest and most restricted Thanetian sea. As this sea continued gradually to increase in size its shores came to occupy the position of the sinuous dotted line running through Reims and Soissons which marks the landward limit of distribution of glauconitic sands with oyster beds and other marine molluscs and characterized by the species *Pholadomya konicki*. The Thanetian sea continued to grow in size and the somewhat glauconitic but often bleached and consolidated sands of this period in its history, which are characterized by *Cyprina lunulata*, but especially by *Cyprina scutellaria*, mark its maximum limits. The broken line of the map that extends through Liège and Namur, east of Reims, swinging westward near Epernay and continuing westward north of Paris and south of Rouen to the present coast near Le Havre, shows the landward limit of distribution of *Cyprina scutellaria* and consequently the minimum limit of the open Thanetian sea at its maximum stage. These sands (*sables de Bracheux*, *sables de Châlons sur Vesle*) pass imperceptibly into the non-marine shore sands of Ostricourt. The solid line on the map running northeast and southwest through Sézanne marks the landward limit of the lagoons along the low coast of the Thanetian sea at its maximum stage of water.

The sea did not stay at this height for any long period of time, geologically speaking, and as it slowly withdrew to the northward, we find these sands overlain with the sand of dunes and of successive beaches marking the various stages of its shores during their retreat to the northward. These sands are interspersed with beds of lignite representing a succession of palustrine or marsh deposits that were formed in the bayous

⁹ Gosselet, J., "Quelques remarques sur la flore des sables d'Ostricourt," *Ann. Soc. géol. du Nord*, tome 10, pp. 100-106, pl. 5, 1883.

of the sluggish rivers or behind successive barrier beaches, and these lignites are interspersed with the plastic clay deposits so common over a wide area in the Paris Basin recording the finer muds contemporaneous with the sands and lignites and deposited in bayous, estuaries, impounded stream-mouths and coastal lagoons. This series of deposits, which are prevailing clays and lignites, and which overlie the marine sands of the Thanetian, commenced to form at the south while the marine deposits were still being laid down a slight distance farther north, and they are younger and younger as they followed the gradually diminishing sea in its course to the northward. These clays and lignites contain many representatives of the

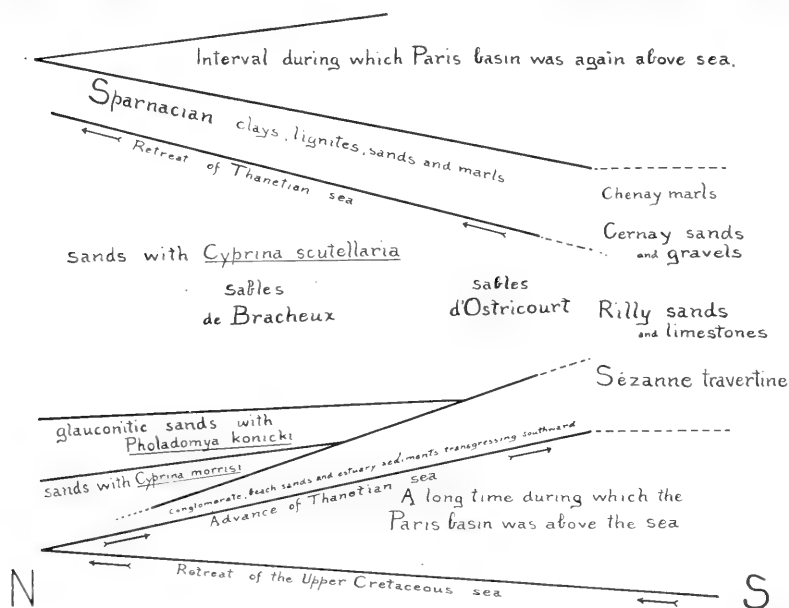
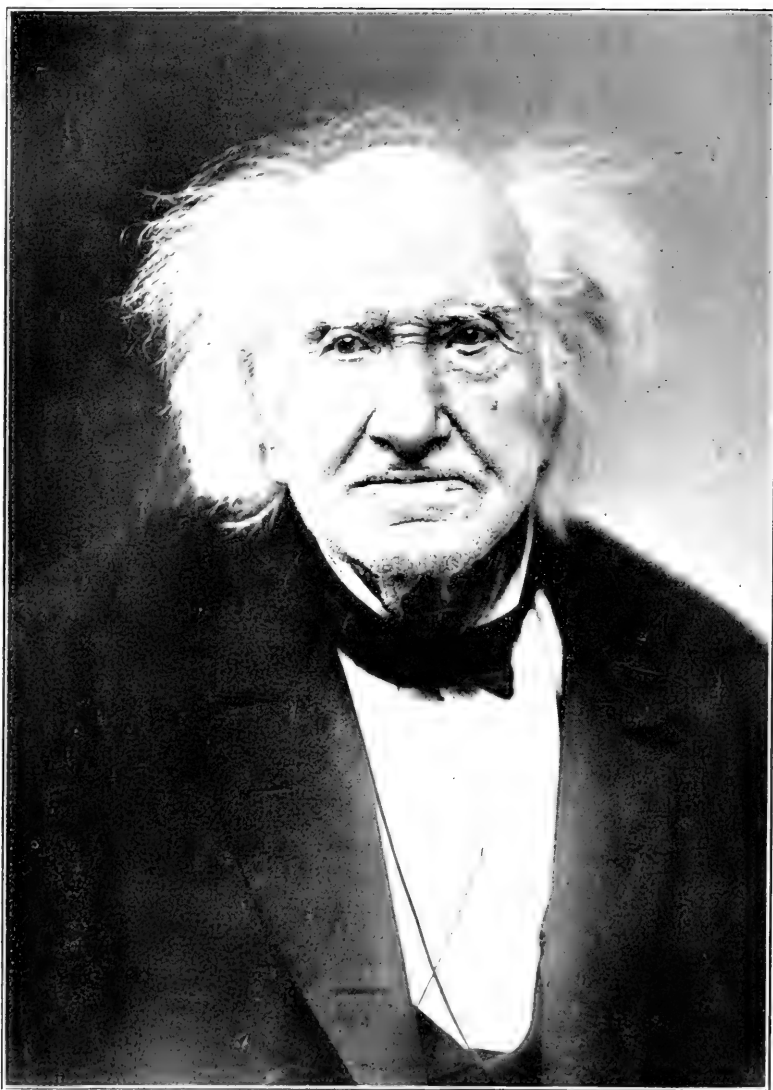


FIG. 3. DIAGRAM SHOWING THE MIGRATION OF THE STRAND, THE STRATIGRAPHIC HISTORY AND THE BLENDING OF MARINE AND CONTINENTAL DEPOSITS DURING THE THANETIAN STAGE OF THE EOCENE.

land animals and plants of the times and because of this fact and the prevailing lithologic character of the deposits, namely, clay and lignite as opposed to the underlying sands, they have usually been segregated as a separate stage under the name Spartanacian, although they really represent the last or prevailing continental deposits of the Thanetian cycle of submergence. Hence some authors group them as a substage with the Thanetian marine sediments and call the larger unit the Landenian stage. A period of emergence during which the Paris Basin was again dry land followed the Spartanacian.

The geological history thus briefly sketched is represented by the diagram shown in Fig. 3, which summarizes the advance and retreat of the Thanetian sea and shows some of the characteristic deposits accompanying these changes, and their relation to the deposits forming at the same time on the land, in the stream at Sézanne and in the Lake of Rilly. Thus what in the first survey of the areal geologist seemed like an unintelligible tangle of sands, clays, limestones and gravels, becomes resolved into an orderly sequence—of great variability, to be sure—but capable of being separated into its component units, each with its page of physical and organic history.

After the facts have been patiently and accurately accumulated in any area it becomes possible to restore the geographic outline of the continent, the confines of salt and brackish waters, the rivers and lakes, the forests, meadows and swamps, and the life that teemed in all of these environments. The successive shifting scenes can often be more readily deciphered than can we understand the gradual changes that are taking place in our own environment at the present time.



MICHAEL EUGENE CHEVREUL.

The distinguished French chemist, long professor of organic chemistry and director of the Paris Museum of Natural History, retiring from the directorship at the age of ninety-three years, though still continuing his professorship. Chevreul's scientific work covers a wide range, but he is best known for his researches on animal fats. Chevreul died in his hundred and third year, the photograph here reproduced having been taken when he was a hundred years of age.

THE PROGRESS OF SCIENCE

CHEMISTS AND NATIONAL SERVICE

THE recent report of a committee of chemists to the Council of National Defense embodies a plan for the training and conservation of chemists and for the utilization of their knowledge and skill in the service of the government. The experience of the other belligerents has shown the wisdom of such foresight. England, France and Italy found it necessary to recall all chemists from the ranks, Canada does not allow them to enlist, and careful observers have insisted that Germany has been saved thus far in large measure through its chemists and other scientific men.

The committee of chemists pointed out the present shortage of trained men in that science, which is becoming more acute through the demands of war conditions. It requires from four to seven years to train a chemist, the longer period being required by those equipping themselves for the doctorate, on whom will fall the vast needs of the government and industries for solving new and difficult problems of research. When the more mature chemists are called into the service of the government, younger men must be trained to fill the vacant positions. The committee of chemists therefore decided that: "It is of greatest importance that steps be taken: (1) To keep and impress into service in chemical lines chemists drawn by the draft for service in the United States Army or Navy. (2) To provide means for keeping open sources of supply of chemists from universities, colleges and schools of technology and to procure volunteers in chemistry."

The plan proposed to attain these ends provides for a committee of three, preferably one industrial chemist, one university professor and one government representative, to advise the President through the War Department on requests for exemptions. Requests for exemptions of individual chemists are to be made to this committee by government, state or municipal laboratories, and heads of manufacturing plants on the basis of the imperative need of these men, or by the presidents of universities, colleges and schools on the basis of the proficiency, promise and ability of students seeking degrees in chemistry. Only students who will receive their doctor's degree by 26 or their bachelor's degree by 23 years of age should be considered for exemption. Chemists under 21 or over 30 years of age, or those between these ages who have not been drafted may enlist as volunteers in chemistry, subject to the same conditions as the enlisted and exempted men. Students under 21 years of age may enroll in a "chemical reserve," subject to the same conditions as obtained for other government reserves. Men thus enrolled shall be subject to the orders of the government as to the location and nature of their service, and, following the practise of France, shall be entitled to wear a badge or other insignia indicating their official status.

Similar recommendations have been made by other committees representing other sciences in their endeavor to place the knowledge, skill and resources of scientific men at the disposal of the government for war service. The representatives of

other sciences have recommended the conservation of the younger men of science by drafting them into scientific service rather than into the army or navy, and have pointed out the importance of abundant provision for the training of additional men of science. Scientific knowledge offers no special resistance to bullets, but when applied to artillery, munitions, transportation, food products or sanitation, it may be the means of saving thousands of lives and millions of dollars.

THE INFANT DEATH RATE AND SOCIAL CONDITIONS

Low wages of fathers and the gainful employment of mothers away from home accompany an excessive death rate among babies in Manchester, N. H., according to the report on infant mortality in that city which has been issued by the Children's Bureau of the U. S. Department of Labor.

The study was based primarily on interviews with the babies' mothers. It was absolutely democratic in scope and included all babies whose births were registered during a single year and whose families could be found. Of all the babies studied, one in six—165 per 1,000—had died during the first year of life. There were wide variations in rate between different groups of the population, according to the fathers' earnings, the employment of the mother, the congestion of the home, and the way in which the baby had been fed.

Nearly half of the 1,643 babies had fathers whose earnings were less than \$650 a year, and more than one eighth of the babies had fathers earning less than \$450 a year. Only one in sixteen (6.4 per cent.) had fathers earning as much as \$1,250. The death rate among the babies in the poorest families

was more than four times as high as among those in the highest wage group.

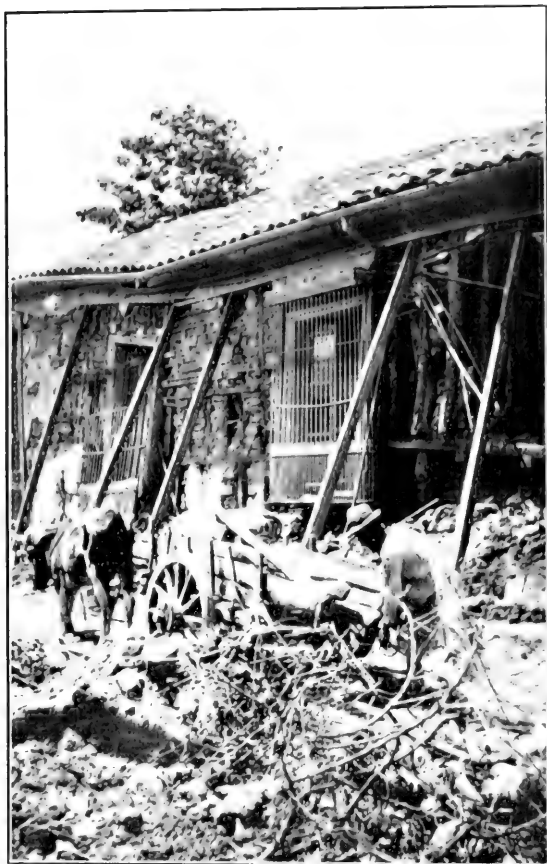
Low earnings on the part of the father appear to be the most potent reason for the mother's going to work. Where the fathers earned less than \$450 a year almost three fourths of the mothers were gainfully employed during some part of the year after the baby's birth. As the fathers' earnings rise, the proportion of working mothers falls, until in the group where fathers earned \$1,050 or over, less than one tenth of the mothers worked.

Keeping lodgers was the chief occupation of those who worked at home, and working in the textile mills was the chief occupation of those who worked away from home. The mothers of 267 babies went out to work during the first year of the baby's life, and these babies had a death rate considerably higher than those whose mothers worked at home, or were not gainfully employed. The rate is especially high—277.3 per 1,000—among the 119 babies whose mothers went out to work before they were four months old.

The babies were grouped also according to the kind of house in which the family lived. The death rate for babies whose homes were in one-family houses was 86.1 per 1,000; in houses containing seven or more families 236.6 per 1,000. Similarly the rate showed a steady increase according to the number of persons per room. It was 123.3 per 1,000 where the family had more rooms than persons; and 245.9 where there were two or more persons per room.

THE SAN SALVADOR EARTHQUAKE

DR. HERBERT J. SPINDEN, assistant curator of anthropology of the



A WRECKED HOUSE IN SAN SALVADOR.



A RUIN OF THE SAN SALVADOR EARTHQUAKE.



"THE FALLING ANGEL," Parque de Duevos, San Salvador.

American Museum of Natural History, in a recent letter to Mr. George H. Sherwood, assistant secretary of the museum, gives an account of the earthquake in San Salvador which occurred on June 7. Dr. Spinden was at the time in Central America engaged in studying and collecting patterns and materials for textiles useful to American manufacturers.

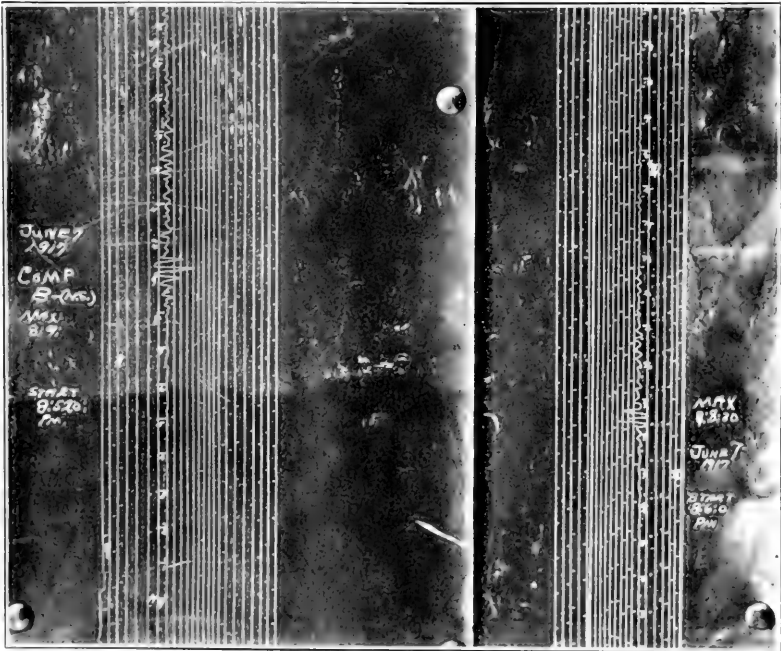
The first shock occurred between 6:45 and 7 p. m. on June 7, and was recorded in New York by the seismograph in the American Museum. Dr. Spinden reports that several shocks followed the initial one

which, coupled with the outbreak of the Salvador volcano, brought terror among the population who crowded from their crumbling homes into the streets and parks of the darkened city. The shocks were not confined to the first day, but continued at intervals with a gradual, though irregular, decrease in intensity for more than a week. Nearly every hour brought a slight tremor, while more violent shocks occurred on June 8, at 10:22 p. m.; on June 9, at 1:00 a. m., and on June 13, at 10:30 p. m. The usual course of a shock was characterized by a rapid rise to maximum intensity, followed

by a gradual decrease or by a series of disconnected tremors, decreasing in violence by slow but frequently irregular degrees. Often, a second shock, called the "echo," followed after a few minutes.

The inhabited regions about the base of the volcano suffered partial destruction, the capital, San Salvador, being particularly unfortunate. Ninety per cent. of the homes were destroyed or rendered unfit for habitation. In many cases the greatest damage was due to the falling of the heavy tile roofs through the inadequate supporting structure. Most of the public edifices, more substantially constructed, suffered but little. Reinforced cement construction stood the test well, while

the lighter types of cement crumbled to earth under the strain. The illustrations, sent by Dr. Spinden to the American Museum and here reproduced, show the extent of the damage. The natives, left homeless, have fitted up temporary shelters of mats, burlap and sheets of rusty tin but with the rainy season approaching, a serious situation may result, unless substantial relief from outside sources is received. The food situation has not been critical since the conveyances of some 25,000 people who fled the city were laden with foodstuffs on their return trips. Temporary distress resulting from shortage of water was soon relieved by the collection of seepage from the broken mains



SEISMOGRAPH RECORD OF THE SALVADOR EARTHQUAKE.

This record is from the instrument deposited in the American Museum of Natural History, New York City, by the New York Academy of Sciences. It shows the vibrations of two separate needles—those of the north-south needle being at the left of the photograph and those of the east-west needle at the right. The north-south needle indicated that the shock was felt in New York City on the night of June 7, 1917, at 5 minutes and 20 seconds past 8 o'clock, while the east-west needle began to register at 6 minutes past 8 o'clock. The time of the greatest intensity of the shock as here indicated by wide vibrations was at 8 minutes and 20 seconds past 8 o'clock.

and by the utilization of artesian wells.

The outflow of the volcanic eruption, while abundant, caused comparatively little damage, since it was largely confined to uninhabited regions. Eight vents opened on the west side of the mountain, sweeping the slope with a stream of lava. A number of coffee plantations on the flanks of the stream were destroyed and, for a distance of two kilometers near Acajutla, the railroad was covered with lava to a depth of 30 feet. For the most part, the region affected is identical with that covered by the last great eruption occurring in 1674. It is said that in some places the old flow has been lifted bodily upon the new.

The San Salvador region is perhaps more frequently visited by earthquakes than any other section of America. In 1873, a shock probably equal in severity to the present one occurred, while more moderate tremors are of frequent occurrence. The accompanying record shows the intensity and duration of the shock of June 7 as recorded in New York City by the seismograph in the American Museum of Natural History.

SCIENTIFIC ITEMS

WE record with regret the death of James Mason Crafts, distinguished for his chemical researches and for a time president of the Massachusetts Institute of Technology; of Julius Otto Schlotterbeck, dean of the College of Pharmacy of the University of Michigan, and of T. McKenny Hughes, F.R.S., Wood-

wardian professor of geology in the University of Cambridge.

A MEMORIAL tablet to the late Dr. S. Weir Mitchell, distinguished as physiologist, physician and man of letters, was unveiled at the recent commencement exercises of the University of Pennsylvania.—A portrait of the late Professor Raphael Meldola is being painted by Mr. Solomon J. Solomon, in order that copies may be presented to the Royal Society and the Institute of Chemistry.—A memorial tablet, including a medallion portrait of the late Sir William Ramsay, is to be erected in the University of Glasgow, of which he was a graduate and teacher.

THE late Mr. W. Hudson Stephens, of Lowville, N. Y., a life member of the American Association for the Advancement of Science since its eighteenth meeting held in Salem in 1869, by the terms of his will has bequeathed the sum of \$5,000 to the association.

THE will of the late Colonel Oliver H. Payne provides bequests of more than \$7,000,000 to charitable and educational institutions. The largest gifts are to Yale University, Lakeside Hospital, Cleveland, and the New York Public Library, each of which will receive \$1,000,000. An endowment of \$500,000 is bequeathed to the Cornell University Medical College. Other gifts include: Phillips Academy, Andover, Mass., \$500,000; St. Vincent's Charity Hospital, Cleveland, \$200,000; Cleveland Jewish Orphans Asylum, \$200,000; Hamilton College, Clinton, N. Y., \$200,000, and the University of Virginia, \$200,000.

THE SCIENTIFIC MONTHLY

SEPTEMBER, 1917

THE WOODLOT: A PROBLEM FOR NEW ENGLAND FARMERS

By Professor JAMES W. TOUMEY

DIRECTOR OF THE YALE SCHOOL OF FORESTRY

HOW to get from the land more of the materials that feed, clothe and shelter mankind is becoming more and more essential with the passage of time. The better use of the land is a basic problem in New England at the present time. The right solution of this problem will maintain her population in the highest degree of comfort, help determine her future greatness and give her the power that makes for endurance. New England's prestige can not rest upon manufacture alone. It must be rooted in the economic development of the land. Germany's position in the industries, developed almost entirely during the past half century, rests upon a firm foundation in land usage. More so than most other nations she has learned how to attain the maximum yield of agricultural and forest products and at the same time she has experienced wonderful industrial development. New England in her fight for industrial development has neglected the foundation upon which it ought to rest. Her land, instead of becoming more productive as years slip by, has become less productive. The acreage used in agriculture is much less than formerly, and the yield per acre astonishingly low when compared with Europe. Her yield of forest products is less than formerly and the quality much lower, due to the practical extinction of virgin forests, the want of adequate protection and the lack of reproductive and intelligent management of the second growth.

The best use of the land requires an adequate conception of what crops, be they agricultural or forest, each particular site is best suited for. Every acre of land unsuited for agriculture that is settled upon and cleared is an economic waste. Every acre of land suitable for agriculture that is left in forest



A 40-45-YEAR-OLD STAND OF NATURALLY REGENERATED WHITE PINE, near Keene, N. H., 10 years after an improvement, thinning which gave a yield of approximately 5 cords per acre, worth \$5 per cord on the stump.

beyond the time when it can be profitably used for the production of farm crops is an economic waste. We who live in New England and are a part of the directing force in her development must clearly appreciate that the sixty-six and one half thousand square miles in the six New England states, all of which were covered with primeval forest at the time of the settlement of the country, consist of two more or less distinct classes of land, viz., agricultural land and absolute forest land. I mean by this that a certain part of the land, due to differences in climate and soil, is most useful and of the greatest economic value when developed for the permanent production of farm crops and another part, when developed for the permanent production of forest crops. Both of these classes of land ought to be developed in a manner progressively to increase the yield of the materials which feed, clothe and shelter mankind. More than 60 per cent. of the total area of New England is classed as forest and, in the opinion of many foresters, the climatic, topographic and soil conditions are such that at least 50 per cent. can be economically developed only when utilized for the production of timber. In other words, more than thirty thousand square miles of New England is absolute forest land—land upon which agriculture has no business, land that will wreck the fortunes of those who persist in utilizing it for purposes which the climatic and soil conditions make it wholly unfit.

How can these vast areas of absolute forest lands be wisely developed and, with the disappearance of the virgin forests, made to produce acceptable yields of second growth timber? Roughly speaking, they are either in large continuous areas in the non-agricultural regions, as in the White Mountains, or in more or less isolated fragments attached to farms in the agricultural regions. The former cover the large uplifts or northern regions of New England, and are largely confined to Maine, New Hampshire and Vermont. The latter are the New England woodlots, for the most part, on soils too poor or too rough for profitable agriculture. They are relatively abundant in Connecticut, Rhode Island and Massachusetts. How much of the absolute forest land in New England is in woodlots attached to farms we do not know. In Connecticut, Rhode Island and Massachusetts nearly all is in woodlots, in Maine a relatively small percentage. On a conservative basis the woodlots of New England include between 10 and 14 thousand square miles, owned in relatively small holdings. Woodlots, due to their comparatively small size, their separation from each other by tillable land, and the abundant, near-by population, should be easily protected from fire. Due to their nearness to market, the stumpage value of wood is usually high and the average quality of the forest soil is such that the yield should be large.

In recent years New England has made some progress in the



A 20-YEAR-OLD NATURAL STAND OF PURE WHITE PINE, near Keene, N. H., 10 years after freeing from overstanding hardwoods, chiefly birch.

organization of her large continuous areas of forest in non-agricultural regions, particularly for fire protection. She has done relatively little in woodlot forestry.

The farmers of New England should appreciate the basic fact that their farms include both agricultural land and absolute forest land. It is just as much the business of the state to encourage the best use of the absolute forest land as it is to do this for the agricultural land. Agricultural colleges, agri-



VIEW OF A 40-50-YEAR-OLD, UNTHINNED, PURE STAND OF WHITE PINE, near Keene, N. H., adjacent to an area recently clear cut, showing the refuse matter after the clear cutting with the larger limbs cut into cordwood.

cultural high schools, farmers' institutes, agricultural experiment stations and country agricultural agencies maintained and supported by the public are a good thing for better agriculture, but they will never serve their full purpose in New England until they help the farmers to a better understanding of the woodlot. The use of the land means the use of absolute forest land, as well as the use of agricultural land; the development of both must go along together.

Agriculture is as old as the race. The farmer knows from long experience that the productiveness of tillable land is measured by the intelligence and labor combined in working it. Nowhere does he expect the grains, fruits and vegetables as a free gift of nature. If we reap we must sow is universally accepted as the foundation of husbandry. Forestry is comparatively new. The farmer is just beginning to learn that the

productiveness of absolute forest land is also measured by the intelligence and labor combined in working it. He knows that the financial yield from 10 acres of tillable land may be as great as that from 100 acres of similar land under less intensive culture. He does not yet know that the financial yield from 10 acres of absolute forest land may be as great as that from 100 acres of the same quality of land less intensively managed. The financial yield per acre of both agricultural land and absolute forest land is chiefly a matter of the crop best suited to the site and of intelligent culture. If the farmer needs national and state aid in order to get the greatest use out of his agri-



THIRTY-YEAR-OLD WHITE PINE AT ENFIELD, CONN., regenerated by broadcast seeding on plowed land of first quality. After first thinning. Number of living trees per acre 767. Number of dead trees 1,004.

cultural land, how much more does he need such aid in order to get the greatest use out of his woodlot, which in New England is a very large part of almost every farm. The vast aggregate area of New England woodlots can not look to national, state, or community ownership or to public regulation for their improvement. Its possibility for future yield rests entirely with the individual private owner. The farmer does not appreciate the economic possibilities that lie dormant in his woodlot. Heretofore, in the utilization of the timber only the superior trees have been cut, the inferior species and those with crooked stems and other defects have been left. At intervals the wood-

lot has been reentered, the exploiters always taking the best trees and leaving the culls. Where wood for fuel could be removed at a profit, the stand usually was clear-cut. In many instances the young growth has been destroyed and only in recent years have serious attempts been made to protect it from fire. As a result there has been a tremendous change in the abundance and frequency of the various species. Thus white pine has practically disappeared from many woodlots where formerly it was abundant; while ash, black cherry, walnut, basswood, tulip, all important elements in the primeval forest, are rapidly disappearing, and gray birch, red cedar, sumac, and similar species of little economic value have vastly increased in both frequency and abundance.

Since the settlement of New England we have been trusting to chance to reproduce our woodlots after exploitation and fires. Acceptable forest stands, however, can seldom be attained by chance any more than an acceptable crop of wheat or an acceptable crop of corn. Forest crops must be intelligently arranged for and the necessary work performed. Although the intelligent farmer does not harvest his crop of wheat one year and expect a volunteer crop the next, it is altogether likely that he will harvest his woodlot and leave it to chance to reestablish a stand upon it. Practically no virgin timber remains in New England woodlots. They are nearly all second growth. Some have been cut over many times dur-



WHITE PINE PLANTATION, 26 years old, spaced 6 \times 6 feet, after the first thinning.
Greenfield Hill, Conn.



WHITE PINE PLANTED UNDER HARDWOODS, near New Haven, Conn. Now in condition for the removal of the hardwoods.

ing the past two and a half centuries, others still retain worthless elements of the primeval stand. They are extremely variable in the character of the stand and in the density of stocking. In species, they vary from the highly valuable white pine to the almost worthless gray birch. The stands are for the most part irregular, open or fragmentary. They are producing but a small fraction of the usable materials that the land is capable of growing.

New Haven County, Connecticut, has, I believe, a fair average of the woodlots of New England. Their treatment has been on the whole no better or no worse than that accorded woodlots elsewhere. The productive power of the woodlots of this county under two and a half centuries of culling and clear-cutting without the intelligent arrangement for an acceptable second growth has been reduced to the point where the average annual cut from the 184,126 acres is but little more than one half a cord of mostly inferior wood per acre. Although close to an excellent market, the average annual financial yield is considerably less than \$1 per acre. Against this yield must be charged taxes, interest charges and the cost of protection. The present average income from the second-growth stands in New Haven county is so low that the farmer is losing money upon them. In other words, the average annual income derived from the 184,126 acres in New Haven county woodlots is

so low that it will not pay the carrying charges for interest on the market value of the land, the taxes and the cost of protection. In many instances, due to the poor quality of the soil and its deterioration through mismanagement, there is no useful growth whatever, the land is absolutely idle and the unfortunate owner must necessarily experience an annual loss.

What can the New England farmer do to remedy the present situation? What can he do to increase the quality and yield of products from his woodlot? It would be grossly misleading on my part were I unreservedly to advocate the removal of the present inferior stands and the establishment of artificial stands by planting more useful species. It would be wrong for me unreservedly to advocate the spending of \$10 or \$15 per acre in an effort to improve the present stands by eliminating undesirable growth through properly arranged thinnings and by seeding and planting the open spaces when the natural growth is too broken for a fully stocked stand. I mean by this that the New England farmer can rely upon no general statement as to what can be done, or what ought to be done in



A MIXED HARDWOOD STAND CUT CLEAR IN 1903-04. The photograph shows the operation of planting in the spring of 1904. Photographed in May. Maltby Lakes, near New Haven, Conn.

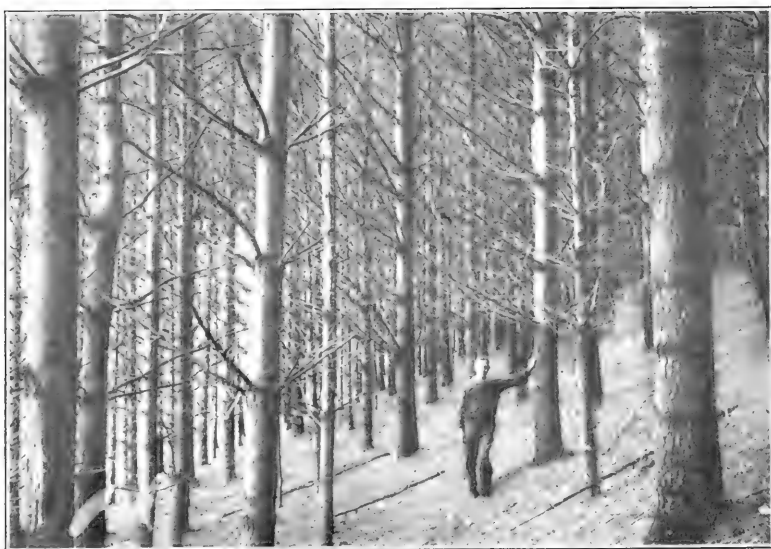


WHITE PINES, 60 TO 65 YEARS OLD.

order to improve his woodlot. Each woodlot is a problem in itself. What and how much the owner can profitably do, in order to attain an acceptable reproduction and take care of it afterward, depends upon a large number of variable factors. The New England farmer must be helped, must be guided in the development of the woodlot. In some localities, as in Keene, New Hampshire, the woodlot can very well become the most profitable part of the farm; liberal expenditures can be made in attaining regeneration, in protection and in thinnings, with the certainty of profitable results. The same expenditures made elsewhere, with different species under different soil conditions and with different markets, would as certainly be an economic failure. The farmers in New England must be shown where the woodlots are that will certainly pay if the necessary expenditures are made to grow the right species in fully stocked stands, properly protected and managed. They must be instructed in the most economical methods for attaining fully stocked stands of desired species. They must be protected against unreasonable tax laws and assisted in protecting their woodlots from fire, insects and fungi. Most of all, however, the farmer must be convinced that what he will get out of his woodlot in the future is measured by the intelligent labor that he uses in its regeneration at this time and in its future management. The New England state departments of forestry have a tremendously large task ahead of them. Their strength and power for usefulness are going to be determined very largely by how fully they are able to convince the farmers of the economic advantage of woodlot improvement wherever such is economically

possible, and how well they are able to lead them along the right course and keep them from economic mistakes. In this work they should join hands with the agriculturist and cooperate with the county agricultural agents. The woodlot owner must be reached on his own woodlot by some one who knows what the possibilities of the woodlot are.

Although at the present time, due to various adverse conditions, many farmers will find it to their economic disadvantage to place their woodlots under intensive management, others, due to the superior location of their woodlots and their suitability for particular species, will find it very profitable. What the farmer needs is more knowledge of forestry. He should know what he is warranted in undertaking with reasonable assurance of economic success.



WHITE PINES PLANTED ON AN EXHAUSTED FIELD.

Keene valley, in southern New Hampshire, is a broad, level stretch of light sandy soil, originally covered with a dense stand of white pine. It has been settled for more than 200 years, and the virgin forest has completely disappeared. The farmers of this valley have been for many years systematically improving the second-growth white pine in their woodlots. Many of these young, even-aged stands of white pine remind one of well-managed forests in Europe. Two years ago a farmer in this valley sold the stumpage on 22 acres of 60- to 65-year-old white pine for \$15,000, or at a price of nearly

\$700 per acre. The average value of 60- to 65-year-old mixed stands of hardwoods in the woodlots of New Haven county is approximately \$50 per acre. In 1871 a farmer near Keene planted a small, precipitous, exhausted field of less than three acres with white pine which was spaced 8 by 8 feet. The land was valued at \$10 per acre. Two years ago this stand of pine was sold for \$1,000. If this land had not been planted, in all probability its rough topography and sterile soil would have caused it to remain idle to the present day. A few days' work in the spring of 1871 has created present wealth to the extent of \$1,000. All over New England there are woodlots that have very large economic possibilities were they properly developed. It is the duty of the forestry profession, through state and other agencies, to force a renaissance in New England woodlots and lift them from their present deplorable, non-productive condition into a condition whereby they will yield in greater abundance and help to solve the problem of the best use of New England land.

THE INFLUENCE OF ARSENIC ON THE BACTERIAL ACTIVITIES OF A SOIL

By Dr. J. E. GREAVES

UTAH AGRICULTURAL EXPERIMENT STATION

SOILS are the earthy material in which plants have their anchorage, and from which they obtain their water and part of their food. They are in reality disintegrated rock, containing, intimately mixed throughout, varying quantities of decaying plant and animal residues. They are derived from the native rocks by a complex process known as weathering. This being the case, we should expect to find within the soil the same substances as were found within the rock from which that soil was formed. Some native rocks carry arsenic in varying quantities; hence, we should expect to find arsenic in some soils, and it has been found to occur to the extent of at least thirteen pounds per acre-foot of soil. It is quite possible if more virgin soils were analyzed arsenic would be found in many of them, and in some in quantities many times as great as here reported.

Furthermore, arsenic is continuously being added to many soils which probably were free from this poison at first. Smelter smoke often contains arsenic, and this finds its way from the air into the soil. Insecticides, such as lead arsenate, Paris green, and many others, are used on many plants and fruits to kill insects. Most of the arsenic of these compounds eventually finds its way into the soil. So we are not surprised to find Headden reporting that he had found in some Colorado soils as much as four hundred and fifty pounds per acre-foot of soil, while Grunner found arsenic to occur in some of the Russian soils to an extent many times this great. An extensive analysis of the sprayed orchard soils of western America showed arsenic to be present in all of those soils and varying from mere traces to five hundred pounds per acre. In some cases it occurred to a depth of three or four feet. But the most interesting fact was that in some of these soils there were even seventeen pounds per acre of water-soluble arsenic. It was not, however, always the case that the greatest quantity of water-soluble arsenic was found in those soils which contained the greatest total quantity of arsenic, for often soils were found which contained only a few pounds per acre-foot, and probably two thirds of it was in a

soluble form. So the conclusion has been reached that some virgin and many cultivated soils contain arsenic in large quantities, but the proportion in a soil is no index of the amount which is soluble in water. The latter is probably governed by many factors; *e. g.*, kind of soil, water-soluble salts in it, and form in which the arsenic was applied to the soil.

That the form in which the arsenic is applied governs largely its solubility is shown by an experiment in which one hundred grams of arsenic in the form of lead arsenate were applied to a soil, and to another portion of the same soil were added one hundred grams of arsenic in the form of Paris green. To still another soil was added enough arsenic in the form of zinc arsenite to make one hundred grams of arsenic. These were carefully mixed and allowed to stand for some time, after which an examination was made for soluble arsenic. The analysis revealed the fact that 14 per cent. of the lead arsenate was in the water-soluble form, 30 per cent. of the zinc arsenite was soluble, but over 80 per cent. of the Paris green was soluble.

Arsenic being in the soil, some soluble and some insoluble, it very naturally raises the question as to what effect it has upon the bacteria of the soil, for we know that any factor which influences these must indirectly influence the crop yield from that soil. This being the case, a number of experiments have been carried on to find out how this substance—arsenic—influences the bacterial activities of a soil, and it is the object of this article to examine a few of the facts revealed by this study.

One of the essential elements for crop production, and the one which is usually in the soil in the smallest quantities, is nitrogen. This, unless it be applied to the soil in the form of the costly fertilizer—sodium nitrate—must be prepared for the plant by bacteria. The farmer finds his crop is limited directly by the speed with which these classes of organisms prepare the food for his growing crop. If they are active, other things being favorable, he will get a good crop; but if they do not play their part, everything else being ideal, there is no crop.

Bacteriological examinations of cultivated soils have shown that usually those which are richest contain the greatest number of bacteria. The number in the soil is dependent upon the quantity and character of the food the bacteria find in the soil. If the soil is rich in plant residues, barnyard manure, and the like, many bacteria will be found there, pulling these substances to pieces, liberating gases and acids which act upon insoluble particles of the soil and render them soluble. One class of organisms changes the protein constituents of the soil into ammonia.

This type we speak of as the ammonifiers. One often detects their activity by the odor of ammonia coming from manure heaps. Now how is arsenic going to affect this normal bacterial process of the soil? The question was answered by adding varying quantities and different forms of arsenic to the soil and noting the results. The answer which came showed that the bacteria were not at first poisoned by the arsenic, but their speed of action was increased. The actual results showed that while the untreated soil produced in unit time one hundred parts of ammonia, soil to which sixty pounds of arsenic per acre was applied produced one hundred and three parts of ammonia in the same length of time. And it was not until 2,500 pounds per acre of arsenic was applied to the soil that the ammonia produced was reduced to one half that normally produced. The Paris green, on the other hand, retarded the action of this class of bacteria even in the lowest concentration added, and by the time 600 pounds per acre had been applied the ammonia produced in unit time had been dropped to one half normal. Thus, we find its poisonous action on bacteria is in a direct relationship to its solubility, and an extremely large quantity of lead arsenate would have to be applied to a soil before it would interfere with the ammonification going on in the soil. But we can not yet say that it is not injurious, for this is only one of the classes of bacteria which are working on the soil nitrogen. Most plants can not use nitrogen in the form of ammonia; it must be in the form of nitrates. This transformation is brought about by two distinct types of organisms. One of them feeds upon the ammonia produced and manufactures nitrous acid. Should the transformation close at this point and nitrous acid accumulate in the soil in large quantities, plants would not grow upon it, for this is a poison to plants. But in soils properly cared for only minute quantities of nitrous acid are found. As soon as it is formed another type of organism feeds upon it and manufactures for the growing plant nitric acid. This, when formed, reacts with other constituents of the soil, such as limestone, and it is ready to be taken up by the plant to manufacture nourishing food, beautiful flowers, or fragrant perfumes for the human family. How is arsenic going to act upon these groups of organisms? In order to find this out various quantities of the different kinds of arsenic were applied to the soil and a determination made of its nitrifying powers, with the result that the untreated soil was found to produce one hundred parts of nitrates in unit time, but the same soil to which had been added arsenic in the form of lead arsenate at the rate of 120 pounds

per acre produced 178 parts of nitrates. Or, in other words, in place of being injured by the arsenic, the bacteria were nearly twice as active in the presence of this quantity of arsenic as they were in its total absence, and it was not until over 700 pounds of arsenic, in the form of lead arsenate, per acre, had been applied to the soil that the bacterial activity fell back to one hundred. Even when arsenic in the form of lead arsenate was applied at the rate of 3,500 pounds per acre there was 68 per cent. as much ammonia produced as was produced in the untreated soil. The Paris green gave similar results. The untreated soil produced 100 per cent. of nitrates in given time, while similar soil to which arsenic, in the form of Paris green, was added produced, under the same condition, 129 per cent. of nitrates, but when higher concentrations of arsenic in the form of Paris green were added it became toxic, and eventually it stopped all bacterial activity; but the quantity added had to be very large, and it is not likely that sufficient would ever occur under agricultural practise.

So we find that arsenic is not injuring the ammonifying or nitrifying organisms of the soil, but how about the other beneficial bacteria of the soil? What effect has it upon them?

There are seventy-five million pounds of atmospheric nitrogen resting upon every acre of land. But none of the higher plants have the power of taking this directly out of the air. We have, however, certain bacteria which can live in connection with the legumes and assist them to take nitrogen from the air. Then we have another set of nitrogen-gathering organisms within the soil which can live free in the soil and gather nitrogen, and they may, under ideal conditions, gather appreciable quantities of nitrogen. It is quite possible that much of the benefit derived from the summer-fallowing of land is due to the growth of this class of organisms within the soil, storing up nitrogen for future generations of plants. For it has been found that they are more active and found in greater numbers in such a soil. All the work which the farmer puts upon the soil to render it more porous reacts beneficially upon this class of organism, for they not only require atmospheric nitrogen and oxygen, which are absolutely essential to their life activities but these must be obtained from within the soil, for the minute organisms can not live upon the surface of the soil; to them the direct rays of the sun mean death. How is arsenic going to influence this class of organisms which are so beneficial to the soil, but are so much more sensitive to adverse conditions than are the other classes of bacteria? Here we find that arsenic in

the form of lead arsenate, zinc arsenite, and arsenic trisulfide, stimulated this class of bacteria, and when arsenic in the form of lead arsenate was applied to the soil at the rate of 500 pounds per acre the nitrogen-fixing organism gathered twice as much nitrogen in unit time as it did in the absence of arsenic. But the Paris green is poisonous to this group of organisms when the minutest quantities are added to the soil, and this is most likely due to the copper and not to the arsenic found within the compound. Hence we find that arsenic stimulates all of the beneficial bacteria. But how does it act? Will it stimulate for a short time and then allow the organism to drop back to its original or a lower level as does alcohol or various stimulants when given to animals? Or will it act as does caffeine—continue to stimulate? From the results on men and horses we might expect the former, for we find that while it is claimed by the arsenic eaters of India and Hungary that the eating of arsenic increases their endurance, and there is considerable evidence to indicate this, it is only for the time being, and if the use be not continued the arsenic eater can not endure the same physical exertion as can others who are not addicted to the drug. Many European horse dealers place small quantities of arsenic in the daily corn given to the horse, as they find it improves the coat of the horse. But if a horse has been dosed for a long time on arsenic it seems necessary to continue the practise; otherwise, the animal rapidly loses his condition.

So we might expect it to be similar with the bacteria, and experiments have shown that, while during the first few weeks the bacterial activity of soils containing small quantities of arsenic is much greater than it is in a similar soil without arsenic, this activity continues to get less until at the end of several weeks it is no greater in soil containing arsenic than in soil containing none. But it is interesting to note that if proper conditions of aeration are maintained it never sinks to a level lower than in untreated soil.

Now why this stimulating influence of arsenic upon soil bacteria? A similar condition has been found to exist when soils are treated with carbon bisulphide, chloroform, or other disinfectants, or even heated, and many theories have been offered to account for it, but probably the most interesting is the idea held by Russel and Hutchinson, who claim that we have within the soil the microscopic plants, bacteria and also microscopic animals, protozoa, and that these minute animals are continually feeding upon the minute plants, with the result that the bacterial plants can not multiply as they could in the absence of these

protozoa. Now when a weak solution of an antiseptic is applied to the soil it kills many of the protozoa, and the bacteria, being no longer preyed upon by their natural foe, rapidly multiply, then as the antiseptic evaporates the few remaining protozoa start to multiply and soon are able to keep in check the bacterial flora of the soil. So we should find within the soil one species preying upon another, and possibly some terrific battles are waged by the microscopic forms of life within the soil, just as these are waged by the higher forms of life upon the earth's surface.

It is quite likely that this is one of the ways in which arsenic stimulates the bacterial activities of the soil. It acts more readily upon the protozoa than it does upon the bacteria, for it is found that soils heated just high enough to destroy the protozoa, but low enough to leave the bacteria unharmed, are only slightly stimulated by the arsenic. After the arsenic has been in the soil for some time it may become insoluble or some of it may be changed by moulds into a gas and pass into the air. Then the few protozoa which have not been destroyed by its presence rapidly multiply and soon hold in check the bacteria.

But this is not the only way in which arsenic acts, for some of the bacteria have become free from the soil and also free from all other plant and animal life, and it is found that these are stimulated so they bring about greater changes in the presence of arsenic than they do in its absence. This is due to the action of the arsenic upon these minute specks of living protoplasm, causing them to utilize their food more economically in the presence of arsenic than in its absence. And this we find is similar to the influence of the arsenic upon the cells within the horse.

Other experiments have demonstrated that the addition of arsenic to a soil causes the liberation of the insoluble plant foods of the soil, especially the phosphorus. So we find arsenic by various means stimulating all the bacterial activities of the soil, and these increased activities, as experiments have shown, are reflected in greater crops grown upon the soil. But this increased growth must be looked upon as due to a stimulant and not to the direct nutritive value of the substance added, and soils so treated would wear out more quickly and produce larger crops than would soils not so treated. But it is interesting and important to know that arsenic has to be applied to a soil in enormous quantities before it retards microscopic plant life, and most likely before it retards the growth of higher plants.

THE DEVELOPMENT OF PUBLIC OPINION IN RUSSIA DURING THE WAR¹

By ROBERT P. BLAKE

PETROGRAD

THE most marked feature in the development of public opinion in Russia since the beginning of the war is the appearance, after an initial period of accord with the government, of a steady and growing dissatisfaction with the ruling circles and their ways. This has culminated not in a revolutionary movement, as one might anticipate, but in an endeavor, by means of the mobilization of the physical and moral resources of the country, to carry the war through to a victorious conclusion.

The organization and unification of Russian society under the pressure exerted by the war has not been as immediate nor as complete as was the case with the other European countries. Towards bringing this about a number of factors have contributed. In the first place, the constitutional structure of the empire, being autocratic in its nature, is opposed, both in principle and in practise, to any movement which is based upon popular initiative. No society of any sort can be formed in Russia without preliminarily submitting its by-laws to the police authorities. Next, the profoundly individualistic nature and non-homogeneous character of Russian society itself has proved a great hindrance to united work. The weak spot has lain not in the work of individuals or of groups, but in the coordination of the work of these groups into a larger whole. It is just in this last point where the greatest progress has been made since the beginning of the war. It forms the latest important development in the social history of the empire. Lastly, but not least, nationalistic troubles have come to check the development of internal unity within the empire. The Jewish question has proved practically disruptive in this regard.

To understand properly the course of affairs in Russia during the war, it is essential to run back to a point some three or four months anterior to the commencement of hostilities, so as to gather up the threads of the later developments.

On the twelfth of February, 1914, Count V. K. Kokóvtsov

¹ Written in the Spring of 1916. We hope to publish an article tracing the later development in Russia, leading to the revolution.

resigned the post of prime minister, and was succeeded by I. L. Goremykin. The change of ministers gave the signal for the beginning of a vigorous reactionary policy on the part of the government, which found its expression in the following lines of action. In the first place, the administration consistently attempted to place a check upon the power of the Duma as a whole, and upon the rights of the members as individuals. Secondly, the press of the laboring party and the leaders of the trade-unions were made the object of a systematic and sharp persecution. Practically all the workmen's newspapers in Petersburg had been driven out of business before the war began by a system of fines, confiscations, and suits brought against the editors.

The conflict between the ministry and the Duma became very acute. Even such a conservative and nationalistic paper as the *Kievlyánin* (March 19, 1914) declared: "We are living upon a volcano." The social democrats and the laboring deputies tried to obstruct the discussion of the budget in the Duma (May 5, 1914), which led to their being excluded from the chamber for the remainder of that, and for the sessions immediately following. The general dissatisfaction thus aroused led to the rejection of the budget by a small majority (148-159; 143-147). This produced a profound impression throughout the country at large. The uneasy feelings thus induced were fostered and sustained by the fermentation which took place within the laboring classes. Strikes began in all the more important commercial centers in Russia. The exasperation of the workmen was envenomed by the merciless persecution which was carried on against their leaders and their press by the government.

Economic questions played a certain part in the outbreak of the strikes, but their political coloring is unmistakable. The leaders of the social democrats in St. Petersburg officially denied their connection with the disorders, and this is probably correct. The workmen themselves, however, admitted the political significance of their actions, and this is proven by the fact that the most serious disorders (St. Petersburg, May 23, 1914), when barricades were erected in the streets, were coincident with the visit of President Poincaré. In view of the later developments, the suspicion of German machinations was and is very widely spread in Russia, but there is no definite proof to settle the question.

In the meantime, however, black clouds had begun to loom on the European horizon. The bloody tragedy of Sarajevo was whole-heartedly condemned by all sections of Russian

society, but the natural sympathy of the country for the Serbians, combined with the evident intention of Austria to make a *casus belli* out of the affair, speedily caused the press and public opinion to swing around. The nationalistic sheets at once began a vigorous agitation in favor of the Serbs; the liberal papers were more reserved.

The Austrian ultimatum to Serbia brought the full seriousness of the situation home to every one, although personal observations firmly convinced me that the mass of the population even then did not believe that it would come to an open break. In official circles the impending danger was recognized upon the receipt of the news that Austria intended to hand in an ultimatum to Serbia. On that same day all furloughs were cancelled; officers were warned to be ready for active service. An official communiqué in the "Russian Invalid" gave notice that the government was most seriously concerned over the situation, while the tone of the nationalist press grew more and more warlike.

The excitement which prevailed in St. Petersburg from the twenty-ninth of July to the first of August, 1914, inclusive, passes all description. Every few moments a new extra appeared on the street; the newsboys were stormed by an excited crowd, and the sheets of paper, still damp from the press, melted like snow before the blast of a furnace. Rumors swept through the city like prairie-fires; nothing was too unlikely to find credence.

The handing in of the German ultimatum to Russia changed the internal situation in the Empire as if by the stroke of a magician's wand. The strikes among the working men ceased with Austria's declaration of war against Serbia, entirely apart from police measures. From the first of August onward all the cities of the Russian dominions were the seats of gigantic patriotic demonstrations: young and old, rich and poor, men, women and children united in expressing their loyalty by word and deed.

The best proof of the latter was afforded by the speed and smoothness with which the mobilization was carried out. In the "historic" session of the Duma (August 7, 1914) only the social democrats, true to their principles, came forward with a protest against the war. All the other groups made declarations testifying to their patriotic feelings.

The only discord in the universal concert, besides the *démarche* of the socialist party, was the somewhat dubious position which was assumed by the *Ryetch*, which is the semi-

official organ of the Cadets (C(onstitutional) D(emocrats)). This took the form of a—to say the least—cool attitude towards Serbia, and an exceedingly restrained—even disapproving—tone in commenting on the policy pursued by the government. This led to a furious polemic between the *Nóvoye Vrémya* and the *Ryetch*, and in the end to the closing of the *Ryetch* for some days. I have full reason to affirm that this was not the attitude of the remainder of the cadet press nor of the party in general, but arose primarily from the sympathy towards the Bulgarians which Milyukóv has always entertained. For this he was subsequently taken to task in his party's caucus, and he there admitted his error. The rooted distrust of the government and its ways which the progressives in general felt presumably played a part here as well.

The readers will easily comprehend the significance and the extent of the alteration in the political situation. This, of course, was not merely a product of the enthusiasm of the moment; other deep-lying causes were at work as well. In order to grasp this fully, we must bear in mind what the previous attitude of the Russian had been towards the German. It was profoundly different from the one which he adopted with regard to other foreigners. It is necessary to make a sharp distinction here between the upper and lower sections of the population. For the peasant the word *Nyémet*s (German) had for two centuries been synonymous with that of oppressor, either in the shape of a government official, or of a stern and unsympathetic factory superintendent; either as an overseer of a landlord's estate, or as a rich farmer, who kept himself strictly apart from the surrounding Russian villages, the population of which looked upon him with mingled envy and hatred. All his disgust and dislike the peasant sums up in the depreciative "*Nyemtchurá*." He terms all foreigners "*Nyémtsy*," as they are the specimens of the breed whom he sees most often.

With the educated classes the situation had shaped itself somewhat differently. In the forties, fifties and sixties of the last century, the tie between intellectual Russia and intellectual Germany was very close and firm. This stage of the development Turgéniev has immortalized in the figure of Bazárov in his "*Fathers and Sons*." After the foundation of the German Empire and the accompanying rise of militarism, we find a change in the order of things. While individuals continued to remain in close touch with Germany and with German thought, intellectual Russia as a whole ceased to feel a close sympathy with Germany. This trend was fostered by the attitude which

was taken by the Germans in the Baltic Provinces, whose inclinations have ever been exceedingly conservative and monarchistic. In the second place, the unmistakable connection between the reactionary movement under Alexander III. and influences proceeding from Berlin caused the sentiments of the intelligent class to cool still further.

Thus we can maintain without exaggeration that neither in intelligent circles nor in the body of the population was there ever the same sense of intimacy or the same fraternizing with the Germans which there has been, for example, with France since 1890. To what extent the government sympathized with Germanophile tendencies it is very difficult to say. A number of actions on the part of certain ministers—notably Maklakóv, the minister of the interior—can only be interpreted in this way. Such are, for example, the extraordinary lenience shown towards the richer German and Austrian subjects who remained in the two capitals, the delay and uncertainty attendant on their being sent off into the eastern governments, the slowness and the evident reluctance of the government to take steps to liquidate the affairs of the German colonists in the southwest provinces, and so on. It is a question here, however, whether it was a matter of personal belief, or whether the German party at the court was not behind it. The latter has been and is notoriously strong; the feeling of resentment both among the educated classes and among the mass of the population is correspondingly fierce and bitter.

Intimately connected with the above question are two others, which have vexed Russian politics unceasingly for the last generation, and which have by no means lost their acuteness at the present time. These are the Polish and the Jewish problems. A line or two about them will not be out of place here: we shall return to them again below.

The words of the Grand Duke's manifesto which promised a new era to the Poles were in general accepted with satisfaction by Russian society. The injustice, mismanagement and oppression on a petty and on a grand scale, which have marked the history of Russian government in Poland, were no secret, but the war seemed to give an opportunity to turn over a new leaf. Officialdom, however, and especially the minister of justice, Shcheglovítov, displayed an attitude toward the question which was more than cool.

The Jewish problem, that festering sore of Russian politics, did not fail to raise its hydra head. The subsidized press, in spite of the general demand from all quarters to cease quar-

relling and get together, continued its attacks and provocative articles against the Jews. Public opinion as yet had scarcely cooled down after the Biélis trial, and the course of events soon gave the anti-Semites new and promising material to exploit.

Such, in brief, is the outline of the situation as it was at the beginning of the war. The government had an unequalled opportunity to solidly unite with itself the overpowering mass of Russian society. Had it chosen to come half way and meet the demands of public opinion, it would easily have made its position impregnable. This, however, was not done. For this failure, in my estimation, two factors were primarily responsible. The first of these was the Russian bureaucrat's rooted fear and suspicion of aught that smacks of popular initiative. The second was the personal character of some of the ministers. I have in view here in particular the head of the cabinet, Goremykin, and to a lesser extent the ministers of the interior and of justice, Maklakóv and Shcheglovítov. People are not agreed in their ideas of the relative rôles which these men played. Public opinion in general is inclined to make Maklakóv the person to blame for the country's losing faith in the ministry. Progressive political circles, however, affirm that Goremykin really pulled the strings, Maklakóv being merely a tool in his hands. In my estimation, this view is nearer the truth. Goremykin, while not a man of real ability, was a clever politician, and got others to pull his chestnuts out of the fire for him. Maklakóv and Shcheglovítov were typical bureaucrats of the narrow type, who knew very well how to utilize the administrative machinery in order to put obstacles in the way of public opinion, but distinguished themselves in no other way.

The development of public opinion since that time has followed two lines. There has been a steady and progressive disappointment in the government and in its actions—not merely regarding the measures which it has undertaken, but likewise on account of those which it has not. The dissatisfaction evoked by this disappointment has found an expression not alone in polemical attacks, and (in some cases) violence on the part of the populace, but (what is more important) in a strong and growing movement towards the mobilization of the strength and resources of the country to aid in the prosecution of the war. This movement owes its origin to the activities of various national organizations. While its development has been under the eye of the government, and the circumstances of war time have compelled the latter to avail itself of the aid of popular initiative, the attitude maintained towards the associations by

the officials has been exceedingly cool. Not seldom have the national societies been forced to overcome the opposition, secret or open, of the ruling authorities.

In spite of the fact that all sections of the populations had solemnly declared that all internal conflicts should be dropped, the subsidized conservative press (*Zémshchina*, *Gólos Rúsi* and their ilk) continued its attacks upon the Jews. The cases of spying where the latter were concerned gave them only too good an opportunity to keep the popular mind irritated. The exceedingly reserved and suspicious attitude of the Jews in Galicia towards the Russian troops did not help matters. The anti-Jewish agitation at this juncture was in itself, perhaps, not such a serious matter, but the close connection between the Polish and Jewish questions gave thinking people cause for serious concern. The Russian press was deprived through the censorship of the possibility of discussing the question of Polish autonomy, while the doings of the local authorities contributed considerably towards dampening the enthusiasm among the Polish population. The manifesto of the Grand Duke gave promise of freedom to the oppressed peoples of Austria-Hungary, and this was formally confirmed by the Viceroy of Galicia, Count A. A. Bóbrinskii. The facts, however, showed the matter up in a different light. The "dregs of Russian officialdom" were sent down to rule Galicia. The nationalist leaders, headed by the active, energetic, but tactless archbishop of Volhýnia, Evlógii, started an active persecution against the Unionist Church in Galicia, in spite of the direct instructions of the viceroy. The metropolitan of the Unionist Church, Count Szeptícki and a number of Ruthenian nationalists were exiled to Eastern Russia.

Along with these nationalistic troubles, the discontent with the government's attitude and actions was given other material to feed itself upon. The governors systematically thwarted the attempts of the population to organize: the swift adjournment of the Duma made liberal circles uneasy. The original intention of the administration had been to prorogue the meeting of the legislative chambers until 1915, but the earnest representations of the deputies caused Goremýkin to reduce this period by half. The renewal of the session was fixed for November, 1914.

Russian society had been disturbed for some time by rumors of a memorandum to the government, in which a number of conservative leaders demanded a speedy conclusion of peace in view of the danger of a revolutionary outbreak. These reports induced the Moscow City Duma to dispatch a telegram to the

Emperor, requesting reassurance on this point. In response to this, a reassuring answer was received. In the meantime, however, the government issued a proclamation in which the blame for the above-mentioned stories was laid at the door of the social democrats. Shortly afterwards the news was published that the police had arrested eleven members of that party in a house upon the Výborg Chaussée near Petrograd. Among them were five of the deputies of the Duma. The trial of the case came off February 23-26, 1915. Although it was proven in court that the members had not adopted the resolution which had been sent from abroad regarding the desirability of the defeat of the government, and had resolved to defer the beginning of any agitation until after the war, none the less all concerned, including the five deputies, were sent into exile. This decision, while properly grounded and motified from a legal point of view, deeply embittered many people. This feeling was intensified by the sentence which was passed upon the well-known emigrant, V. L. Búrtsev, at about the same time. The latter had returned to Russia to serve his country, and had been arrested at the frontier. He was brought to trial on the old political charges against him, and likewise exiled. Shortly afterwards the Russian Economic Society was closed. It is the oldest learned society in the country, with the exception of the Academy of Sciences, with a century and a half of honorable career behind it. Later on the minister of the interior, A. N. Chvostóv, admitted that the reason was that the Society "had become a center of public movement."

The facts mentioned above induced in the Duma at its reopening (January, 1915) a feeling radically different from that prevailing during the August session. In place of the enthusiasm which had then exalted the members, the deputies had now become intensely conscious of the real seriousness of the situation. The extreme difficulties with which the army was already contending in regard to ammunition supplies were beginning to become known. The members who had just returned from the front pictured the situation in the darkest colors, and showed how things really stood. General Suchomlínov affirmed that "everything was going all right," which declaration was later on branded as a "deception of the Imperial Duma" (Milyukóv's speech, August 1, 1915). At about the same time rumors of the shortage of ammunition began to circulate among the population.

A second matter which gave serious alarm to public opinion was the rapid rise in prices, which was particularly swift

during the months of November and December, 1914. The enormous extent of the Russian Empire, with its relatively scanty population, and weakly developed railroad system, makes it very difficult to meet and overcome by means of timely hauling any economic shortage. In addition to this, two of the main trunk lines which lead to Petrograd were almost wholly monopolized by the military authorities. The traffic organization of the Russian railroads had never been what it should be, and now, under the stress of war conditions, it became thoroughly disorganized.

A rise in prices on imported goods was of course inevitable, and was received more or less philosophically by the public at large. The steady rise in prices on food-products, however, touched each separate individual in the population in his most tender spot. This was the more acute in Petrograd, as the immediate territorial surroundings of the city are very poor in an agricultural way; meat and butter, for example, are brought almost exclusively from the Don Basin and from the Baltic provinces, respectively. The storekeepers naturally took advantage of the situation, and began to force up prices, while the approach of cold weather, combined with the scanty supply of wood on hand, caused all to view the coming winter with alarm.

After the January session of the Duma the public organizations began to bestir themselves in earnest, but it was the retreat of the Russian armies from Galicia and from Poland, beginning in the end of April, 1915, which gave a new and mighty impetus to this movement. Under pressure of misfortunes on the field of battle, the discovery of the Myasoyédov conspiracy, and the lack of ammunition, a state of mind fraught with grave consequences began to pervade the country. The government decided (rumor has it that General Yanushkiévitch, the former chief of staff, was the author of the measure), in view of the many instances of espionage which had been proved against the Jews, to expel the entire Jewish population from the territory immediately contiguous to the field of military activity. At the same time the "Black Band" papers continued and increased their *pogrom* agitation, scattering broadcast accusations of treachery against the whole race. Simultaneously with this a vigorous campaign was carried on against the Germans in the Baltic provinces, in which very questionable elements assumed the lead. The agitation had been begun by the *Nóvoye Vrémya* and some of the other papers. At first numbers of prominent men took part in the "society for the conflict with German oppression," but, in view of the dubious

character of the leading spirits in the enterprise, they speedily dropped out.

Overstrained nerves gave way in the outburst at Moscow (June 8-10, 1915). The true history of this affair has not yet been written, and perhaps never will be. Various versions are current as to the cause of it, but it is clear that no one factor is to blame for all the trouble. Many were evidently at work. What actually happened was the plundering and wrecking of six hundred and ninety-two business places and factories. One hundred and thirteen concerns belonging to German and Austrian subjects were destroyed, while five hundred and seventy-nine stores of Russian, English and French firms suffered. The police took no steps whatever to stop the plundering, but stood calmly by and watched. The mob turned its attention at first to those stores which belonged to subjects of the hostile powers, but later pillaged whatever came their way. On the third day the intervention of the troops put a stop to the affair.

The above-mentioned circumstances brought about a strong feeling of discontent with the government on the part of the population. What is more important, however, it likewise aroused a determination in the more vigorous circles of society to better the situation. The instruments which served for the furtherance of this project were those general national organizations which had existed previous to the war, such as the *zemstva* and the charitable, professional and learned societies, and more especially those new ones which had arisen during it. Of these the most important were the "General *Zemstvo* Alliance" and the "General Municipal Alliance."

The first of these societies was formed at the congress of delegates from the *zemstva* at Moscow, August 12, 1914. Prince G. E. L'vov, who had stood at the head of the *zemstvo* relief work during the Russian-Japanese war, and had then shown his talents as an organizer, was placed in charge. From the very first the alliance declared that the local peasant industry (weaving, shoemaking, etc.) should be organized and mobilized for the needs of the army, that the *zemstva* should take over and administer the requisitioning and preparation of food products and the like, and so forth. The ministry of the interior, however, put hindrances in the way of the development of the activity of the alliance, while the military authorities did not see fit to accept the offer. For this Russia later paid a shocking price in blood and money. The alliance was forced to confine itself to the organization of the care of the wounded, which the war department was not able to handle at all. At the end

of ten months (June 18, 1915), Prince L'vov was able to report that the alliance was maintaining (primarily on the basis of government subsidies) one hundred and seventy-five thousand cots for wounded soldiers, fifty-five special sanitary trains, and field organizations in all parts of the front.

Not long after the appearance of the *zemstvo* alliance came the formation of the municipal alliance. This was founded at the meeting of "town heads" (mayors) in Moscow, August 23, 1914. At this gathering it was pointed out that there was urgent need of intermunicipal action in order to regulate the distribution and transportation of food products. Here also the government put the same hindrances in the way of the extension of the field of the new organization's activities, and the municipal, like the *zemstvo*, was forced to turn its activities exclusively to the care of the wounded. Up to the end of the year 1915 it maintained seventy-six thousand cots and thirteen special trains in operation.

The difficulties which were met with in solving the problem of the large cities of the empire gave a new impulse to the activities of the two alliances. The minister of commerce and industry, Timashyóv, was dismissed (March 2, 1915), and his place was taken by Prince V. N. Shachovskói. The central provision committee, which was under the control of this ministry, was given special powers (April 14, 1915). Popular initiative, however, did not rest here. At the meeting of the Municipal Alliance in Moscow (April 19, 1915), the delegates appointed a commission to work out a plan to regulate the provision supply for the municipalities, while at the congress of the delegates of the produce exchanges and the agricultural unions, the ex-minister of commerce and industry Timiryázev and Prince Shachovskói laid strong emphasis upon the need of good relations between government and society so as to continue their coordinated work.

The continued misfortunes which overtook the Russian army in the field spurred the development of this movement. The deputies of the Duma began to insist that the legislative chambers be called together before the date mentioned in the ukaz announcing its adjournment (November 20, 1915). The congress of the representatives of commerce and industry passed resolutions (June 7, 1915) calling for the immediate mobilization of all the manufacturing resources of the country for the needs of the army. This impulse later developed into the gigantic industrial organization known as the "Industrial Committee for the Furnishing of Military Supplies for the

Army," through which are fulfilled all contracts made by the government in Russia. The effort of the government to put the affair on a primarily official basis was pronounced to be insufficient by public opinion; it was demanded that the *zemstvo* and the municipal alliances should also take part in the work. Lastly, they went on record that the Duma should be convoked without delay. At about the same time a number of different congresses were held, all of which insisted that the government must be responsible to the people.

The leaders of the different groups in the Duma met in the cabinet of the president of that body, and passed a resolution that the president, Rodzyánko, should see the premier about summoning the Duma as speedily as possible. Goremýkin agreed in principle, and, after a certain amount of delay, the ukaz summoning the legislative chambers was issued (July 22, 1915); the opening date of the session was fixed ten days later on.

In the meantime a very extensive reconstruction had taken place within the ranks of the ministry. The minister of public instruction, L. A. Káso, who had kept the Russian educational world in a state of continued irritation by a series of indirect and petty repressive measures, had died, and his place was taken by Count P. N. Ignátyev (January 9, 1915). The latter has so far made a very creditable record in his office. By the use of common-sense and good will he has succeeded in ameliorating the relations between the ministry and the schools to a notable degree. Immediately previous to the convocation of the Duma, the personnel of the ministerial bench underwent a serious alteration. June 18, 1915, the minister of the interior, Maklakóv, who had drawn more ill-will upon himself than any of his colleagues, was suddenly dismissed. Prince Shcherbátov was appointed as his successor. June 25 followed the resignation of General Suchomlínov, the minister of war, now under trial on the charge of high treason. His place was taken by the very able and popular General A. A. Polivánov. July 17 V. K. Sábler, the procurator of the Holy Synod, left his post, which was assumed by A. D. Samárin, the leader of the Moscow nobility. Lastly, July 31, the minister of justice, I. G. Shcheglovítov, was replaced by Senator A. A. Chvostóv.

In so far as these dismissals were the means of ejecting undesirable individuals, they unquestionably tended to satisfy public opinion, but as far as marking a change in the internal policy of the government, they had not the slightest significance. With the exception of General Polivánov, who, all agreed, was

the right man for the right place, the new men in the ministry were all from the conservative *zemstvo* circles. While themselves honest and upright, they did not possess the confidence of the country, because not men alone were needed, but the policies for which they stood.

Goremykin, however, did not approve of the idea of a reformed ministry such as was proposed by the Duma. While granting that the government and the Duma must needs work together, he declared that only such bills should be brought before the legislative chambers as were directly concerned with the needs of the war. All measures which were aimed at "the bettering of the conditions of Russian life in times of peace" were to be shelved for the time being. One exception was made (belated at that!) for the question of Polish autonomy.

The deputies who succeeded the premier on the speaker's tribune of the Duma did not agree with this attitude, but pointed out that the government could only gain the full union and confidence of the people by satisfying some of the more pressing popular demands. A significant example of the state of mind within the Duma itself was afforded by the elections of new members to the committee on army and navy affairs. The old commission resigned, and in its place new elements came in from the left side of the chamber. The able and energetic constitutional democrat, A. I. Shingaryov, was made its chairman. The attempt of the conservative elements to formulate a program based solely upon the conflict with German oppression and the rise in prices did not meet with the approval of the majority of the Duma.

In general there now began to appear strong symptoms of discontent with the results of the session of the Duma. As ever, Moscow proved the true barometer of Russian politics. A number of conferences (private in their character) preceded the meeting of the Moscow municipal Duma of August 27, 1915. Four resolutions were adopted on this occasion, of which the substance is as follows:

1. Moscow has full confidence in our valiant army and in the Grand Duke, and will uphold them and back them up to the last man.

2. The whole population must set themselves to work for the needs of the army.

3. A close and vital union between the government and the people is necessary. Moscow is certain that the Duma is able and willing to do its share in the matter.

4. A government is necessary which is strong through the

confidence of the people, and must be headed by a person whom the people can trust.

The majority of the members in the Duma were already approaching the positions which the Moscow resolutions had marked out. At the meeting of party leaders (August 19, 1915), a plan had been brought forward by the constitutional democrats of laying out a general scheme of intended legislation for the further work of the Duma. This project, in a somewhat altered form, forms the substance of the declaration of the progressive *bloc*. After a very heated discussion, it came out that the center and moderates of both wings were agreed to adopt some such plan. Neither the extreme radicals nor the extreme conservatives would give their approval to the project. In the course of a number of conferences the party leaders worked out the program of the progressive *bloc*. This was published September 6, 1915, in the Moscow; September 7 in the Petrograd papers. As this document marks a turning point in the evolution of the subject which we are treating, it is incumbent upon us to devote some attention to it.

In substance its demands are as follows:

A ministry should be formed which has the confidence of the country.

The policy of the government should be based upon and directed by its trust in the country. In particular, the administration should be conducted according to the laws of the country (and not according to ministerial circulars). The activities of the war department should be restricted to its own province. The personnel of the local administrative forces should be subjected to a thorough renovation.

In regard to certain points in the internal administration of the Empire, a tolerant, intelligent and consistent policy should be adopted by the government. All political and religious trials not directly connected with the war should be stopped. All exiles who have suffered as a result of such prosecutions should be allowed to return at once. All legal measures tending to restrain freedom of belief contrary to the ukaz of April 17, 1905, should be reversed.

Touching legislation on nationalistic and class questions, the press is to be restored. The Finns are to have mild treatment, and the staff of Russian administrative officials must be altered. The persecution of Finnish officials is to cease. The Little-Russians should have their press restored to them. The inhabitants of Galicia who are detained under arrest shall have their cases examined at once. The trade unions shall be allowed

to function once more. The persecution of the labor leaders and of their press shall be stopped.

In legislative matters there shall be complete agreement between the government and the Duma. All laws connected with the war are to be put through without delay. Certain other laws whose primary object is to further the organization of the country for victory should be worked out and put through the legislative chambers as soon as possible. Such are the income tax; a law concerning reforms in the structure of the *zémstva*, and the foundation of the same in the Caucasus and in Siberia; a revision of the law on cooperative societies; a regulation of the rest-hours for workmen; a raise in salary for the postal employees; absolute prohibition of vodka; a reform of certain points in judicial procedure.

This declaration was signed by the leaders of all Duma-groups from the nationalists to the constitutional democrats inclusive.

The appearance of the *bloc* on the scene created a sensation. The conservative press fulminated and raged: the extremists on the left cursed the moderate radicals and branded them as renegades for their alliance with the center, while much of the radical press criticized the program of the *bloc* from one point of view or other. In general, however, public opinion assumed an expectant attitude, and waited to see what might befall.

The cabinet hesitated for some time as to the position which it should assume. Goremýkin endeavored to get the conservative forces to form a *bloc* to support the government, but the leaders of the nationalists and the "octobrists" informed him that they were bound with the agreements which had previously been made. The leaders of the *bloc* had a conference with the comptroller of the Empire, P. A. Charitónov, a man universally respected for his ability and character. The latter laid the matter before the ministers. The opinions in the cabinet were divided. Most of the ministers spoke in favor of the *bloc*, but Goremýkin and the minority were against any concession.

The premier left for headquarters (September 10, 1915) to consult with the emperor, and returned two days later with the ukaz announcing the adjournment of the Duma on the sixteenth of September. Excitement ran tremendously high, but the Duma and the population preserved their sang-froid. The official and semi-official press endeavored to interpret this as a sign of the powerlessness of the *bloc*. The *Kolokól* (September 18, 1915) remarked: "The Duma has adjourned, but the popular sea is calm, and its waves as of old break indifferently on the shore."

Popular initiative now left the precincts of the legislative chambers and transferred its activities to the meetings of the *zemstvo* and municipal alliances in Moscow (September 20, 1915). On this occasion the policy of the government in dissolving the Duma was strongly condemned, and its lack of faith in the people was bitterly deplored. Both congresses chose a deputation to express their feelings in the matter to the Emperor.

The assumption of the chief command of the Russian armies by the Emperor (September 4, 1915) gave the signal for a reactionary movement. This found immediate expression in the reconstruction of the ministerial bench which followed. The procurator of the Holy Synod, A. D. Samárin, resigned his post (October 7, 1915). Simultaneously with him, Prince Shcherbátov, the minister of the interior, was dismissed. The latter's place was taken by the leader of the conservatives in the Duma, A. N. Chvostóv. The departure of the second minister was due, according to the *Nóvoye Vrémya*, "from reliable sources," to his disagreement with the premier on points of internal policy. In the last days of his holding office, he was forced to deny an audience to a deputation from the *zemstvo* and municipal alliances which desired to consult with him on questions which "lay outside his political competency." Chvostóv probably owed his nomination (very unexpected to everybody) to his speech in the Duma on German oppression (November 7, 1914). Lastly one of the more moderate members of the cabinet, Krivoshéin, the minister of agriculture, was dismissed, and his place was taken by A. N. Naúmov, a candidate from the most conservative circles of the nobility.

That the population was discontented with the turn affairs had taken was evidenced by the elections to the Imperial Council, where the representatives of the *bloc* gained twelve new members. Among them were such progressive leaders as Prince E. N. Trubetskóï, P. P. Ryabushínskii, and A. I. Gutchkóv. The members appointed later were all strictly conservative.

To counteract this defeat, black band circles began a vigorous campaign against the progressive *bloc* under the leadership of the ex-minister of justice, Shcheglovítov. They declared that the members of the *bloc* were conspiring to overturn the government under the pretext of passing the most necessary legislative measures; likewise that they disregarded the words of the Emperor, "all for the war." Presumably in connection with this, the meetings of the municipal and *zemstvo* alliances, which were to have been called in Moscow in December, were

prohibited by the governor. The summons of the Duma was deferred by the ukaz of December 7, 1915, until the work of the budget commission should be completed.

The effect of the retreat of the Russian forces from Poland upon the public had been tremendous and shattering. The swift fall of the fortresses of Novo-Geórgievsk, Warsaw, Kóvno, Gródno, Brest-Litóvsk and Vílna, one after the other, had strained the nerves of the population to the highest point of tension. The inhabitants of Petrograd in particular disgraced themselves by a display of undue and exaggerated nervousness, but the same holds true to a certain extent of the rest of the country. The retreat was brought about solely by the shortage of ammunition, and stopped when the factories were in a position to supply the same. None the less, stories of treachery were flying about, and the words *pódkup* and *predátel'stvo* (bribery; treachery) were on every one's lips.

The halting of the German advance at the end of September, and the successful attack of the French and British on the German lines in Champagne calmed things somewhat, but in place of excitement and alarm came the inevitable reaction. A period of supineness set in. This feeling was strengthened by the reactionary policy which the government followed, by the economic difficulties in the way of obtaining food and fuel, and above all by the vast wave of refugees (*byézhentsy*), which flooded all the eastern governments. Four millions of unfortunates, in most cases wholly without personal effects, and practically destitute of means, were driven from their homes and forced to seek refuge in the more distant parts of the empire. The relatively speedy and successful distribution of this human avalanche was primarily due to the efficient work of the two alliances and of other private organizations.

The quartering of the refugees upon the villages caused a serious disturbance in the economic life of the country. Prices on food and lodging rose at once: the refugees themselves, being mostly women and children, and moreover receiving pecuniary support from the government, were by no means inclined towards field labor. The widespread dissatisfaction thus evoked among the peasantry forced the government to devote to it its most serious attention.

In the meantime the financial commission of the Duma had got the budget ready. The approach of the time for the convoking of the Duma was heralded by the resignation of Gore-mýkin. He was succeeded by B. V. Stürmer, a member of the Imperial Council, who had served as a governor in various parts

of the empire. He was noted as having been an enemy of the *zemstvo*, but, so far as any one could see, had exhibited no other capacities which could fit him for standing at the helm of the government at such a critical time. That he was a safe conservative goes without saying. A hint of his political alignment was given by the fact that he did not make a formal visit after his nomination to Count Ignatyev, the minister of public instruction, who was the one member of the cabinet who was on good terms with the progressive *bloc*. People were of course glad to get rid of Goremykin, but to get Stürmer in his place was, as one wag remarked, to get the king of clubs instead of the king of spades. Shortly afterwards A. N. Chvostov (the minister of the interior), who had started on his career with a great amount of talking to the newspapers, but had practically done nothing, was also dropped. Much more serious was the resignation of the minister of war, General Polivanov. Officially the matter was connected with disorders which occurred at the Putilov Iron Works, but there is no doubt that court intrigues played the largest part here. It was and is bitterly deplored by the country at large.

The Duma was at length summoned at the end of February, 1916. It was soon evident that the *bloc* was working well together. The attitude of the government and the *bloc* towards each other was one of armed neutrality, which was not specifically altered by the unexpected visit of the Emperor to the Duma. What the true significance of this very astonishing event was is impossible to say, and those who are best informed doubt if the Emperor was quite sure himself.

The *bloc* succeeded in getting the income tax law through the Duma and the Council; the cooperative bill passed the Duma before the Easter recess. The attacks on the *bloc* from the left and the right have not ceased, nor have they lost in vigor. The other general points for which the *bloc* is striving have not been attained, nor can they be, while a ministry of the present type is in power.

What, then, are our general conclusions to be with regard to the situation, past and present?

As regards the parliamentary side, we must note that for the first time in the short course of Russia's parliamentary history, a working coalition majority has been formed, which has proved its cohesiveness and ability under very adverse circumstances.

As regards national organizations, they have shown their vigor and capability in dealing with a series of very difficult

problems, in spite of an unsympathetic attitude—at times even direct hindrance—on the part of the government.

As regards the administration, the war has shown up its weakness and its disorganization, while more clearly than all else it has evinced its ability to adapt itself to new and unforeseen conditions.

As regards Russian society proper, and more particularly the thinking class, it has not, in my estimation, displayed itself in a very good light. While energy and enthusiasm have not been wanting, it has shown itself lacking in the persistency and will-power which carry a thing through to the bitter end. The want of intelligent general organization has made itself felt in every department of public activity. Unpreparedness played a large part, and government stupidity and obstruction have done their share, but Russian society must come in none the less for its share of the blame. On it alone must be placed the responsibility for the panic-stricken state which enveloped the Caucasus during the Turkish advance upon Sarakamýsh; which prevailed in Petrograd and Moscow during the German drive on Poland. This holds true more for the larger towns: the peasantry, especially of those districts which lie near the seat of military activities, have shown a much better and more determined spirit.

Thus the war has proved a great teacher. Along with the millions of lives which have been lost, and the tens of thousands of towns and cities burnt and destroyed, the people have been compelled to organize and to take command of the situation. After the war, without doubt, there will be great changes, whatever the outcome may be. For those true friends of Russia, who realize her faults, but love her for her good qualities, it is a source of consolation and encouragement to feel that the united forces of her people, brought to the light amid the thunder of the cannon and baptized in the tears of her suffering millions, have set firm foot on the road of progress, even though the goal be still distant. They alone, if it be possible for any one, shall bring it about that the developments after the war can expand along the lines of constitutional growth, and not take the form of a social deluge.

PATTERNS FOR PEACE OR WAR

By ELSIE CLEWS PARSONS

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I

AMONG the Zuñi of New Mexico certain rites for the dead are performed on a day the Indians call *ahoppa awan tewa*, "the dead their day." Bits of food are dropped in the fire by the women of the household and larger portions are taken by the men to a sacrosanct place on the river flowing into the lake under which, the Zuñi believe, live their dead. In the pueblos of a kindred tribe the food offerings are heaped at the foot of the cross in the center of the cemetery attached to the Catholic Church. A cross stands in the cemetery at Zuñi also, but at Zuñi the Catholic Church has been disestablished for almost a century—long enough for the Zuñi to believe that *ahoppa awan tewa* is utterly disconnected with Catholicism, that it is a ritual they have had, as they say, referring to their myth of subterranean origin, "since they came up."

Ahoppa awan tewa is, nevertheless, All Souls' Day and, whether the Zuñi took it over two or three centuries ago from their own Catholic priests or whether they copied it more recently from Mexican or from Mexicanized Indian acquaintances, it is a striking little illustration of acculturation, of that process of borrowing by one culture from another, which to the contemporaneous ethnologist is the most alluring and the most baffling of researches. Acculturation, the ethnologist will tell you, goes on whenever two different cultures are in contact, and he has an abundance of evidence, familiar and unfamiliar, to present to you. According to what rules acculturation goes on, however, why certain customs or beliefs or techniques are assimilated, and others ignored, why in assimilation there is now close imitation and now transformation, of the answers to these questions and to many others of a like kind the ethnologist is uncertain. As yet about the best he can do is to suggest—he would be sure to make the suggestion in the case of the Catholic rite at Zuñi—that borrowing is facilitated by a certain degree of preexistent resemblance; by the presence of cultural pegs, so to speak, on which the cultural novelty may be readily hung. At Zuñi, for example, centuries before the arrival in

1539 of Fray Marcos of Niza, the dead were prayed to and to them property was dispatched. To introduce a new occasion for prayer or gift was not difficult. The Cross itself, where in certain pueblos the gift was made, was a familiar symbol in ancient pueblo art. In other words, suggests the ethnologist, the success of a cultural innovation probably depends on the pre-existence of a cultural pattern, a pattern of belief or of practise, into which the alien belief or practise may be fitted.

This hypothesis in the theory of acculturation I would apply in brief to the contact between European culture and American culture since the great war and in particular to the contacts of their respective militarist and pacifist patterns.

Given the pacifist mood or character of the United States in the summer of 1914 and the present disposition of the country, it can hardly be questioned that of all the nations this nation has since the outbreak of the war covered the longest stretch of militarization. Its peace patterns have been very successfully invaded by militarist patterns. The theory of militarism that physical compulsion should be the preferred way out of social misunderstanding or incompatibility has been fairly well acculturated throughout the country. In a remarkably short period a system that would suppress by physical means or quasi physical means minority opinion at home and conflicting opinion abroad has been adopted. The plans for international arbitration that in very recent years had been to the fore were readily dropped, discredited outright or deferred until after the war, to be embodied in that love child of militarism and pacifism, namely the League to Enforce Peace. At home, principles of toleration for minorities, of freedom for conscience, of freedom of speech, of *lehrfreiheit*, of no discrimination against "race," principles which for a comparatively longer period had been under cultivation in the United States, these principles were also dropped, dropped with a facility amazing to many. In view of these facts, it is fair to say, I think, that European militarism, in so far as it is a theory of social adjustment, has been quite well established among us.

Why has this acculturation of militarist patterns been so facile, so unopposed? Is it because of preexistent resemblances, perhaps of patterns which lent themselves to militarism? Certain features of American life do give color to this theory. Negro disfranchisement, segregation and lynching suggest that racial discrimination is not altogether alien to American practise. A number of instances in the treatment accorded He-

brews might also be cited in this connection, as well as certain attitudes towards immigrants, particularly immigrants from southern or southeastern Europe. "Americanization," whether conscious or unconscious, is characterized not only by racial discrimination, it insists on homogeneity, and the homogeneity or like-mindedness it demands permits of so little variation that we are led to question whether respect or tolerance for minorities in general is a notable American trait. Those intellectual and moral timidities which are so notable, on the other hand, among Americans are not readily accounted for in the absence of intolerance of dissimilarity or dissent. As for freedom in teaching or discussing, would any radical who has had experience of editors, trustees or other agents or exponents of public opinion venture to say that American taboos were not peculiarly binding on speech or thought? What radical is not well aware that any charge of "atheism" or "free love" or "anarchism" or syndicalism, if taken seriously, will endanger his or her position or livelihood?

To be sure, the heterodox in religion, ethics, politics or economics are not always banned, for they are not always taken seriously. As long as they are accounted infertile or inconsequential they are tolerated. And as indifference to opinion, scepticism of opinion *qua* opinion, is a feature of American life, a large measure of tolerance appears to prevail. It is only when the practical man loses his contempt for the theorist that he becomes intolerant. But let the innovating theorist forget his place by any chance, the place where he is inconsequential, and he may count on quick suppression. For him the price of existence is remaining ornamental.

The ornamental radical is not only tolerated, he is even welcome, for he flatters the spirit of the practical man, giving him not only a sense of superiority in common sense, but a sense of tolerance. The practical American likes to think of himself as tolerant. The American, practical or theoretical, regales himself on catchwords and of all his catchwords "liberty" is one of the most precious. The American remains the child or rather the veteran of the eighteenth century and such eighteenth-century formulas as "liberty"—or "equality" or "fraternity"—he still refuses to examine. Indeed he even goes on applying them uncritically to fresh conditions—like the present war.

The present war, we hear, is being fought for liberty, for freedom from German rule, for the independence of small nations, to set the world free. The validity of these statements

I am not for the moment concerned with. I would merely indicate that war for human liberty is so familiar an American concept that any war, once it had taken on this aspect, would pass unquestioned. Once the European War was classified as a war for liberty with the war of American Independence or the Civil War, the European war was acculturated. None has understood this process better than the President. We are using the flag, he declares, as we have always used it, not for some new purpose but "for some old, familiar, heroic purpose for which it has seen men, its own men, die on every battlefield upon which Americans have borne arms since the Revolution."¹ Again, on June 5, at the annual reunion of the United Confederate Veterans, the President, after referring to ourselves as "an instrument in the hands of God to see that liberty is made secure for mankind," adds:

At the day of our greatest division there was one common passion among us, and that was the passion for human freedom. We did not know that God was working out in His own way the method by which we should best serve human freedom—by making this nation a great, indivisible, indestructible instrument in His hands, for the accomplishment of these great things.

From the point of view that the Revolutionary War was the beginning of a series of wars for freedom or that the Civil War was a divine preparation for the European War, the spirit of the European War is made thoroughly at home. As the Zúñi would say, "it has been with us ever since we came up."

II

Catchwords, in supplying a link between the old and the new or in making the new appear one with the old, seem to be a factor in acculturation. Catchwords may supply still other face-saving masks for conduct. I call to mind the not uncommon formulaic use of the term militarism. In the very moment of making vast appropriations for armament or for war, of declaring war or condemning discussion of peace, of voting conscription or establishing military drill in the schools, Americans would reiterate, "Never shall we become a militarist people." I confess to a feeling of impatience when first I heard this claim to what seemed like mystical immunity, and to making the obvious and futile retort, "But what are we now?" But before long I began to examine the claim or assertion, an assertion so plainly comforting to its makers that it compelled

¹ From a Flag Day speech reported in *The Times*, June 15, 1917.

examination. Was the assertion merely that of the infantile shirker saying, "This once, but never again; one lie will not make a liar, one misdeed will not affect the character?" Or was there, after all, some significant inarticulate self-realization under the childish expression? Is there, not certainty, but possibility that despite our efforts we shall fail of becoming a militarist people?

Are there, indeed, in this country any peace patterns that will prevail, at least in certain circumstances, against the militarist patterns—perhaps not in theory, but in practise? Militarist theory we have already adopted, but have we made up our mind to practise the theory at all costs?

Before trying to answer this question I would like to consider the one definite reason sometimes advanced for the belief that militarism can not prevail in the country. Militarism requires a caste system, it is argued, and caste does not develop in the United States. The argument appears to rest on another American catchword, or if you like, ideal, the ideal of equality. Not being an idealist, I can not help realizing the existence of the American caste system, and foremost in it the existence of the plutocratic caste. In plutocratic circles I see an element out of which a militarist caste might easily form. I refer to the rich by inheritance, the sons of the rich. Men of the second or third generation of wealth are peculiarly adrift in our society, having in it no particular place or power. Compare the sons with their self-made fathers and even with their mothers and sisters and wives. The fathers are not only rich, they are plutocratic. They get a sense of power from their wealth—power in finance, in business, or perhaps in naïvely and arbitrarily changing the face of nature. As for the women folk, they too, given the gynocratic conditions of American "society," they too enjoy power or the sense thereof. But for the husbands or sons of gynocrats or plutocrats there is little or no opportunity to count. Patrons of science or of the arts they may become, but then such patronage yields little social recognition in communities where science and art have of themselves small claim to distinction. Socially destitute and jobless, the sons of plutocrats and the husbands of "society queens," business men gone to seed, as Veblen has dubbed them, would seem² to be promising recruits for a militarist caste.

² In June I was present at the closing exercises of a certain well-known boys' "boarding school." On the platform sat a bishop and other clergy, a judge, and an historian. "You are here, boys, as in an officers' camp," were the words of one orator and the tenor of all. "You are to

Given eligible recruits, will the caste form? It is quite likely to form, I think. Recruited from the plutocracy, American army and navy officers will gain greatly in prestige, their social position, as we say, will be very much improved. Their distinctive points of view, their code and their etiquette will gain in definiteness and assurance. The profession will become even more exclusive than it is now, exclusive of persons who do not accept uncritically its boundaries and standards and outlook. In such exclusiveness and in such prestige we have the main characters of caste. But to what extent will such a militarist caste influence or control the community at large? On the answer depends the conclusion as to whether or not "we become a militarist people."

It is not possible, I think, to look far ahead in this matter. Militarism in school and more particularly in nursery may transform social values in a comparatively short period so that in time militarist standards may take the place at large of present-day plutocratic standards. Until that substitution takes place, however, our military, reconstructed and reinvigorated though it be, will be kept under by the very class to whom it owes its renaissance, by finance and business.

Not that the American plutocracy will refrain from developing its own militarist polity. But it will be merely a polity to its own advantage, and the military will be merely its tool. No doubt recent history will be repeated. It was the plutocracy supported by the military as well as by satellites in the other professions who "willed participation" in the European war. The plutocracy had profited greatly from the European war. As long as this profit was uninterrupted, American business as a whole looked to the administration to keep the country out of war. But when war profits were threatened by submarine attacks and still more importantly by the psychological effects of these attacks, when railroads and docks were congested and commerce seriously threatened, war was demanded. The declaration of war against Germany was essentially a declaration that American business would be protected.

American business prospered upon war in Europe. Rather than submit to the checks upon this prosperity imposed by the submarine, American business preferred declaring war. But be the captains of your country." . . . "Study history," said the historian, "the value of the study has just been proved. It is thanks to us with our knowledge of history that the masses in this country are now at war."

Military drill has been introduced into this school, let me add in the words of its rector, to develop "patriots who are preparing themselves against war."

with the country actually at war, burdened with war, will American business continue to prosper? That is the real issue for war or peace current in this country to-day. It is a question of economics. Upon whom will the economic burden of this war fall? If the war tax system paralyze business, as we say,³ instead of stimulating it or diverting it into new channels, business will turn against war. Under a heavy excess-profits tax business men would become pacifists. Under a confiscatory surplus income tax the plutocracy as a whole would turn pacifist. But if taxation merely divert business, if it merely suggest new ways of expending income; if taxation fall upon the little man, upon the subject economic classes, then the ruling economic class will hold out for war. War will continue to mean profit, economic or "social," an asset for income or for prestige, an occasion for "fairs," benefits, and committee organization, an opportunity for persons anxious to give proof of their social worth.

The effect of war upon business is the touchstone in this country for the desirability of war. Activities other than business, less valued activities or interests, war may injure without serious consequences to a militarist polity. Science, the arts, experimental education, experimental government, may be damaged with impunity, their hold or appeal is so slight. As for the other activities or interests of life, many of them, like philanthropy, for example, will be merely diverted by war, many of them will be even stimulated, for example, parental and kinship interests, sociability at large. Gregarious satisfactions war enhances, for other satisfactions war creates substitutes, it is only the economic satisfactions which are positively curtailed by war. In this war, upon what class in America is the curtailment to press? Who will pay the bill of the war, not the bill in terms of life or spiritual suffering, but the bill in economic terms, in terms of labor or property?

If, paradox though it seem, the ruling class is unable to make the subject classes pay, the ruling class will suffer a change of heart towards the war. And there is a chance that the plutocracy may fail, fail either through bond issue or taxation, to make outsiders pay. The failure, should it occur, would be due to the absence of the stock war patterns of fear or of its offspring hate. Fear of invasion is not really felt through-

³ Thereby, of course, becoming economically an inefficient system. I would not dispute the fact that war taxes which are oppressive of business are from the point of view of war revenue undesirable.

out the country,⁴ nor is desire for reprisal as yet telling. Plutocratic representatives have been well aware that in this sense America is not awake, and they have been at some pains to stimulate the stirring emotions. "I feel that people are not altogether awake to the seriousness of this war," declares the president of a great bank, adding:

We are in a very serious war, war that might even come to our own shores.⁵

Another banker says:

I pray that whatever may be needed to arouse us . . . will come to us, so that we may realize that we are to-day not only fighting for the principles upon which our Republic was founded *but for our very existence*.⁶

Under the caption of "A Call for Righteous Hatred to Aid our Awakening" a trustee of the American Defense Society, a well-known New York lawyer, writes:

Let us summon to our aid [in understanding the pan-German plot] two motive powers which have not yet been enlisted—fear and hatred. . . . Every justifiable basis of both fear and hatred exists to rouse America to the implacable determination that at the cost of her last man and her last dollar Germany must be destroyed. . . . We also must slay or be slain.⁷

During the fantastic sale of the government's first war bond issue government aviators dropped circulars pleading for the purchase of war bonds which read:

It might have been a German bomb. To avoid Bombs, buy Bonds.

To further promote the sale of the bonds the Secretary of the

⁴ Given the huge numbers of Germans among us and our preference for German immigrants, it is somewhat difficult to arouse panic over further invasion, even on the premise that such invasion would be by the German government, not by the German people. Europeans critical of the distinction so greatly popularized in this country between the German government and the German people overlook the necessity of the distinction. Germans viewed as "people" are too familiar and too well liked to fear, it is only Germans viewed impersonally and mystically as "government" that can inspire the indispensable terror.

⁵ From a Liberty Loan speech by Frank A. Vanderlip, *New York Tribune*, May 22, 1917.

⁶ From a Red Cross speech by H. P. Davison, *New York Times*, June 16, 1917.

⁷ Letter to the *New York Tribune*, June 5, 1917.

Treasury suggested that the German invasion would mean retreat into the interior and payment of half the wealth of the country as an indemnity.

The secretary, the lawyer and the bankers appreciate that to make war without the aid of unimpaired war psychology is a difficult if not an impossible task. In any country of modern culture but the United States it would indeed be impossible. Here where the hold of "ideals" is so strong, where between ideals and reality no connection is sought, war ideals may substitute for war emotions. To make the world safe for democracy, to fight for civilization or humanity, or, gem of idealist abstraction, to fight for the brotherhood of mankind, are ideals that may succeed as stimulants to war—at least for a time.

In a war run on ideals, however, there is peculiar danger of defection. Given a sharp enough experience of hardship or privation, mysticism may give way to a sense of reality. In this case American shrewdness may get the better of American ideals, or, rather, "common sense" may conclude that idealism, no longer its servant, must be repudiated. The slogan, "A rich man's war" is ready made. Then, unless war patterns other than the pattern of idealism have been established, a struggle may ensue to put the burden of the war on the class who willed the war. The war spirit of reprisal, if not turned upon the alien, may turn upon those at home deemed responsible for high prices and heavy taxes.⁸

Were large groups, labor or small-business groups, to seek in consequence to escape from under the war burden, perhaps to effect a radically different distribution of wealth, the plutocracy would be alarmed. Indeed it might be alarmed enough to look instinctively for new ideals for peace. It might declare that war against "socialism" was a holier war than war against Germany, that the autocracy of socialism was more dangerous to civilization than the autocracy of any one government.

Hitherto anti-war individuals or groups have been accounted pro-German, hence negligible. Were anti-militarists to turn their attention away from peace terms to changing the distribution of the war burden at home their efforts could no longer be discounted as pro-German. Their efforts would be taken seriously. Their efforts would be generally described in

⁸ Already a note of warning has been heard. "The pacifists have singled out the rich as mainly responsible for the war," writes a New York banker. "It may be due, consciously or unconsciously, to a resulting feeling of resentment that the proposal to confiscate during the war all incomes beyond a certain figure is actively promoted by leading pacifists." ("Some Comments on War Taxation," by Otto H. Kahn.)

Mr. Kahn's terms as "practical socialism under the guise of war finance." Then in self-defense the plutocracy might come to desire peace. Preserving the social order would seem more important than a war to end war. To make the country safe for plutocracy would become more urgent than to make the world safe for democracy. The slogan, Peace for Democracy would disposses the slogan, War for Democracy. At any rate democracy, that democracy which is the opposite of socialism, begins, we should hear, at home.

Dread of socialism or of currents setting strongly towards socialism may end the present war for the United States^o—but what of future wars? Will the plutocracy have learned its lesson for peace if it has to pay the bill? Will militarism be discredited in its eyes? No indeed—social lessons are not thus learned, learned for good, either by classes or by nations. The only effect upon the penalized plutocracy would be to inspire it to preparedness, to preparedness against having to pay the bill for the next great war it might desire. An important part of that preparedness will be developing a nationalistic spirit. In this the reconstructed military will be of service. A series of "little wars" will also be of service. They will be wars to keep patriotism vigorous and distracted from anti-plutocratic home enterprises, wars to give an army and navy based on universal service something to do, and wars to benefit commerce and finance. In other words, they will be wars for the good of "backward" peoples. Thus for the good of others we may become a militarist people without knowing it until some day, perhaps in a century or so, the then League to Enforce Peace, shall we say, or internationalized Europe turn against us and, like Germany of the twentieth century, we find ourselves with a fight against the rest of the world on our hands.

^o Although not necessarily for European nations. To the ruling classes in Europe socialism is more familiar and less abhorrent than to the ruling classes in the United States, much less of a bugaboo. And then the ruling classes of Europe have been impressed together with the subject classes with the patterns of fear and hate, so that they are willing to make class sacrifices. That these class sacrifices are only temporary they may also believe.

IMPORTANT FACTORS IN THE QUESTION OF RESPONSIBLE BEHAVIOR

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IT can not be emphasized too strongly at the outset that the question of responsibility is fundamentally a question of native endowment given emphasis and direction through the quickening influences of an ever-impinging environment.

That the emphasis as here suggested is by no means generally palatable is abundantly attested by the prevailing practices in organized educational agencies for the development of normal human beings and in the specially organized corrective agencies having to do with wayward youth, still plastic; and having to do with hardened adults whose character and habits have set like the plaster on our walls. Nor will such emphasis become universally tasty until subjective standards, points of view, are effectively displaced by the non-personal, the rigidly objective. Among other things such a reversal in standpoint involves complete abandonment of all forms of anthropomorphisms and the frank acceptance of physical and perhaps mental continuity. The children of man in such a view are regarded as the offspring of parents representing the culmination of the organic series of creation and are endowed with characters the ancestry of which, in the final analysis, reaches the plummet of evolutionary history. Such a view makes man and his children integrally related with the world—establishes kinship in open acknowledgment. Moreover, it involves the abandonment of an aprioristic transcendental moving principle which comes from nowhere, but is somewhere located in the human body. Obviously, educational leadership in so far as it operates under such a principle and from an anthropomorphic standpoint is false as measured by modern empiricism and by the test of conceivability as science knows the test.

McDougal¹ in commenting on such a materialistic view of behavior observes:

Under these conditions, the working hypotheses of the natural sciences become confidently held doctrines from which we feel ourselves able

¹ McDougal, "Mind and Body," p. 144. The writer does not wish to convey the misleading inference that this quotation represents McDougal as holding a materialistic position; in its original setting the complete paragraph fits McDougal's animistic beliefs.

to deduce the limits of the possible; and we seem able to rule out from our scheme of the universe all that confused crowd of obscure ideas which, under the names of magic, occultism, and mysticism, have been at war with science ever since it began to take shape as a system of verifiable ideas inductively established on an empirical basis. Once admit, on the other hand, that psychical influences may interfere with the course of physical nature "you don't know where you are," you can no longer serenely affirm that "miracles" do not happen; they may happen at any moment and may falsify the most confident predictions of physical science. Thus the gates are opened to all the floods of spiritualism and superstition of every kind which . . . seem to threaten to light up once more the fires of persecution and to drag down our civilization from its hardly-won footing upon the steep path of progress.

A frank adoption of the objective standard to which I have referred requires a knowledge of the architecture, function and endowment of the human organism. No teacher should practise the art and certainly not the science of education, no social reformer should attempt reformation, who does not possess some information regarding the psychophysical nature of the creature to be taught or reformed. To know the structure, function and general endowment of the human organism; to appreciate its physical relationship to the world in which it lives and to believe that the springs of action and behavior are essentially internal; these constitute the irreducible prerequisite to an intelligent understanding of responsible behavior. Not until then will the army of educators, penologists, criminologists, philanthropists link the question of responsibility and the function of punishment with an *a posteriori* view of the educative process. Least excusable is the absence of such orientation in higher education, for it is here that prospective teachers and social workers should acquire a viewpoint which is consonant with modern science.

It should also be emphasized that the human organism, in common with all living organisms, is immersed, as it were, in a sea of environmental stimuli which unlock the human organism's inherited forces which form its dynamic energy. The question of the relation of environmental stimuli and innate energy and the rôle of each in the development of the final adult behavior lies near at hand.

The current and historical views regarding the efficiency of each or both of these factors in human development may be sufficiently classified into three groups: (1) The absolute efficacy of hereditary characteristics, (2) the absolute efficacy of the environment, and (3) the joint product of native endowment and environmental stimuli.

The first view involves the belief in a rigid physiological

teleology in which the end, *i. e.*, adult character, lies embedded in the matrix of inheritance. In this matrix is found the *termini a quo* and *ad quem* of behavior. From this point of view the adult character, as the culmination of its resident end, potentially exists in embryonic life and each stage in its development may be regarded as a fatalistic realization of this character. The budding, developing child grows unerringly according to inherited mandates lodged in its constitution; this growth takes place without let or hindrance which may be devised by organized social agencies. In such a view the pre-organized adult elements of behavior constitute active forces seeking out from among the environmental sea of nature's stimuli those destined, by the scheme of things, to actualize these elements. A fitting dictum for such a position is: "A silk purse may not be made out of a sow's ear." "Hewers of wood and drawers of water" are with us, always have been, always will be and this because of unequal endowment, certainly not by reason of the absence of social and educational opportunities.

Logical consistency would seem to require that the exponents of this view push the intrinsic character backward beyond the given infant to the entire strain which constitutes its long lineal descent. Variety of character, it would seem, is bounded by the varying degrees of dominance of the elemental characters comprising the strain. Each fertilized egg of such a strain may represent a unique combination of self-sufficient forces which spin themselves to adult realization according to intrinsic laws. But the designation of such forces as 'self-sufficient' or 'self-determined' are as empirically barren as an entelechy or any of the tribe of animistic principles. Empirical demands are perhaps more completely satisfied when the forces are regarded as chemical correlates or perhaps better as dynamic relations in which the integrative factor is some dominant metabolic wave or gradient of activity.²

There is much in the world which lends color to such a view. In the biological field consider certain of the modern conceptions, such as the congenital tendencies to criminality or the tendency of supernormal persons to insanity. Move a little higher up (or a little lower down, depending on your point of view) on the social ladder and consider the millions of social derelicts who are unable to carry their own load in the world, millions more who are scarcely able to cling to the

²E. M. Child, "The Basis of Physiological Individuality in Organisms," *Science*, N. S., Vol. XLIII, pp. 1-12.

sod of bare subsistence. These cases typify the dictum that "some mortals are not so much born into the world as damned into it" and lend color to the belief that man is *in toto* a product of the virile determinants lodged in his constitution. The inevitable consequence is clear—constitutional limitations whether of the over- or under-emphasis variety with certain surety consign such mortals to the lowest rung of the ladder of responsibility, and this constitution is the terminus which can not be transcended by pedagogical devices, however adept the pedagogue or refined his tools. Here dispositional tendencies appear as protruding energies *seeking out* mechanically or animistically, as you will, that environment which is appropriate for their realization. That environment which is relatively or wholly disregarded is viewed as non-contributory to the actualization of innate tendencies. From this point of view, education is not so much a 'drawing-out process' by organized or unorganized educational agencies as it is a 'drawing-in process,' in which the environment plays a passive rôle. What we find here is an operation strictly internal.

Frankly, this view makes an end of individual responsibility and prohibits punishment. In so far as the question can become a question at all it must rest with the immediate or remote progenitors of the individual. What we actually find here is an infinite regress in which each member of a pair of progenitors points to his father and mother as responsible for the character he possesses. We find in this view a fatalism so rigid as to make utterly futile the efforts of organized and unorganized educational agencies for the betterment of mankind.

That our theologians have overlooked this modern form of biological predestinarianism does not argue favorably for their argumentative brilliancy.

Fortunately such an extreme view shows the usual fate and merit of all extreme views in that out of the extremity there remains a workable precipitate which may be followed with safety. Causal efficacy of the factors involved in the determination of adult character will of course vary endlessly; now it will be given to heredity, now to environment. As illustrative of the emphatic, though by no means representative of the extreme view referred to, insistence on the hereditary factor, the views of A. J. Rosanoff³ are quoted. Speaking of the alcoholic adult character he says:

How does one become an alcoholic? The prevailing view is that through example, or suggestion, or by way of sociability, one is initiated and eventually habituated to the use of alcoholic beverages in gradually increasing amounts.

³ Lecture given before the Psychology Club, Ohio State University.

This is true as far as it goes; but it is equally true that under *any given conditions*, favorable or unfavorable, some persons will and others will not become alcoholic; the difference is between the persons. A great many can drink and even drink to excess without becoming alcoholic, in the specific sense of the term.

To become an alcoholic one must not only drink alcoholic beverages; one must be "alcoholizable." Being "alcoholizable" seems to consist of a constitutional weakness, derived from *bad heredity*.

Heredity, therefore, is not only the direct essential cause of probably two thirds of all cases of mental disorder, but is indirectly responsible for most of the alcoholic cases as well.

Bad heredity is thus the cause of causes, and upon it must be concentrated the bulk of preventive effort.

Among the measures that have been advocated for the prevention of bad heredity, the most important are restriction of marriage, sterilization, and segregation.

Segregation is not only practicable, but also effective; and we are justified in telling our legislatures that mental health is purchasable; mental disorders can be reduced by dollars and cents spent for segregation in this generation.

The mental disorders now prevailing amongst us are the heritage of untold generations of neglect of segregation.

The views of Rosanoff are extreme, but not of the extremist to which I have referred.

The apostles of the extremist view when confronted with the practical question, What is your prescription for the betterment of mankind? What is your recipe for the development of responsible human behavior? replies that the 'gladdening oil' must be put upon the 'squeak' far below the stage of adult existence. The source of human supply, the procreative function, is the fulcrum under which the lever of human uplift must be applied. Sentiment and sympathetic bosh must give way to cold calculation which rests on eugenic authorities if race recruiting is, in the main, to be other than from submerged families. Organized charities and corrective agencies alleviate those 'damned into existence' but in no wise prevent the constantly recurring 'damnation.' From the non-emotional point of view there is here "much sweetness wasted on the desert air."

There is no surcease from this stream of sorrow until the "legislative representatives of all the people" seek guidance from eugenic authority for the enactment of remedial legislation to prevent the propagation of those predestined to give steady employment to the 'social lifter.' Until such legislation becomes operative social betterment can only be of the temporary variety, that is, only for the existing crop of social derelicts. Social alleviation under existing laws and conditions is literally an endless process of bailing out the boat without

stopping the leaks. The increase in crime and irresponsibility generally would seem to indicate that in no distant future the leakage in bids fair to exceed the bailing out. In Ohio, according to recent statistics, the jail population in the decade 1906-1916 increased to the disquieting extent of 42.0 per cent.⁴

The second view, namely, the absolute efficacy of environment, is obviously so obsolete in responsible scientific circles that it may be dismissed without further consideration. This view, like the preceding, view fails to avoid the 'falsehood of extremes.'

If we adopt the third view, the position that behavior is the joint product of native endowment and acquired responses, we find not only individual, but collective, responsibility as well. It is then that the 'tail' of behavior goes with the 'hide' of inheritance and experience. This view is a compromise conclusion between the strict hereditarians and eugenicists who insist that immediate conditions control the destinies of men.

The compromise position maintains that the first essential to responsible behavior demands that every infant shall be well born, free from the heavy hand of incurable diseases which, with fatal surety, ring the death knell of efficient if not honorable existence. Important as is the factor of birth, no one except the restricted group to which I have referred, I think, would maintain that desirable birth is a safe insurance against irresponsible behavior; beyond affording a secure foundation for character formation no social virtues perhaps can be claimed for it.

The fact to be emphasized here is that a desirable hereditary soil is but a part of the problem of responsible behavior. That this is not the whole of the problem becomes clearer when it is remembered that the weeds of irresponsible behavior also thrive and strike deep their roots in such a soil. Witness the unconvicted, expert, intelligent criminals in certain of our professions. The terms 'shyster' and 'quack' readily suggest themselves. These social weeds are not indigenous to imbecilic or even moronic soil. It is equally important that every child be well reared. This is, in part, society's function. No one, I think, would seriously maintain that the rise and fall of past civilizations, in any other sense than contributory, are results of feeble-mindedness, nor, I think, will it be seriously maintained, unless normality has disappeared, that the fifteen (more or less) men who two and three fourths years ago

⁴ T. H. Haines, "The Increasing Cost of Crime in Ohio," p. 8.

plunged the entire world into an unparalleled sea of blood and sorrow, depriving thousands of helpless babies of their feeding-bottles, were irresponsible because of congenital, incurable diseases. Nor does it seem probable that the greatest dangers which may befall our great republic lie in the irresponsible conduct of our feeble-minded population. One so-called responsible, well-bred (not well-educated) directing head of an influential metropolitan newspaper, or a glib-tongued, self-seeking, not-very-near statesman may rock the underpinnings of society far beyond the combined influences of an entire state's population of derelicts. This, the most dangerous form of irresponsibility, is a plain matter of brain organization. The brain considered prior to formal organization is endowed with certain powers and capacities—inborn traits—which through environmental conditions become specific habits of response. What the schools or any other social agency probably can not do at all is to create intellect, to create capacities; the most that may be expected by any form of environmental influences and conditions is to determine the channels in which innate intellectual traits shall become specific. In other words, how a normal human being specifically behaves depends upon the after-effects which environmental forces leave in the bodily tissues, more especially the nervous tissues. The ethics of an individual probably does not transcend the bundle of habits acquired by outward agents impinging upon the sense-organs and originating nerve-currents which channel their way, as it were, through the brain to the muscles. The effect of such a process by virtue of the extraordinary plasticity and retentivity of neural tissue remains a permanent possession of the body so long as the tissues endure. Any line of print or talk falling upon the eye or ear-gate leaves its indelible, ineffaceable imprint and becomes a lasting determinant of conduct. The sum total of these determinants grouped and classified into more or less specific habits of greater or lesser degree of perfection constitutes and circumscribes character.

The entire body seems to be made over, seems to undergo a molecular readjustment by the kind of environmental nourishment to which it responds. Carpenter⁵ long ago pointed out that the organism grows to "the mode in which it is habitually exercised." It is proverbial that this 'growing to' process, this organization of the brain to respond in definite ways, takes place most readily during childhood when the bodily tissues are extraordinarily plastic and retentive. It is clear that early

⁵ "Mental Physiology."

anti-social brain-organization gives rise to pitiful attempts at reformation later. Carpenter goes on to say that what is early learned "becomes branded in (as it were) upon the cerebrum; so that its 'traces' are never lost, even though the conscious memory of it may have completely faded out. For, when the organic modification has been once *fixed* in the growing brain, it becomes a part of the normal fabric, and is regularly maintained by nutritive substitution; so that it may endure to the end of life, like the scar of a wound."

The late William James⁶ in his incomparable style expresses the results of Carpenter's 'growing to' process as follows:

It (habit) alone is what keeps us all within the bounds of ordinance, and saves the children of fortune from the envious uprisings of the poor. It alone prevents the hardest and most repulsive walks of life from being deserted by those brought up to tread therein. It keeps the fisherman and the deckhand at sea through the winter; it holds the miner in his darkness, and nails the countryman to his log-cabin and his lonely farm through all the lonely months of snow. In most cases, by the age of thirty, the character has set like plaster, and will never soften again.

Again James says:

The hell to be endured hereafter, of which theology tells, is no worse than the hell we make for ourselves in the world by habitually fashioning our characters in the wrong way. Could the young but realize how soon they will become mere walking bundles of habits, they would give more heed to their conduct while in the plastic state. We are spinning our own fates, good or evil, and never to be undone. Every smallest stroke of virtue or of vice leaves its never so little scar. The drunken Rip Van Winkle excuses himself for every fresh dereliction by saying, "I won't count this time!" Well, he may not count it, and a kind Heaven may not count it; but it is counted none the less. Down among his nerve cells and fibers the molecules are counting it, registering and storing it up to be used against him when the next temptation comes. Nothing we ever do is, in strict scientific literalness, wiped out.

Pathological cases are not wanting which indicate that the brain is endowed with this extraordinary degree of retentivity and that every sense stimulation reaching the brain leaves its undeniable trace there. Some of these impressions seem to sleep in the brain tissues like the camera's picture sleeps in the collodion film to be revived only by unusual conditions of cerebral disease or accident. The case cited by Coleridge and quoted by Carpenter and James is illuminating.⁷

In a Roman Catholic town in Germany, a young woman who could neither read nor write, was seized with a fever, and was said by the priests to be possessed of a devil, because she was heard talking Latin, Greek and Hebrew. Whole sheets of her ravings were written out and found to

⁶ "Principles of Psychology," Vol. 1, pp. 121, 12.

⁷ "Principles," Vol. 1, p. 681.

consist of sentences intelligible in themselves, but having slight connection with each other. Of her Hebrew sayings, only a few could be traced to the Bible, and most seemed to be in the Rabbinical dialect. All trick was out of the question; the woman was a simple creature; there was no doubt as to the fever. It was long before any explanation, save that of demoniacal possession, could be obtained. At last the mystery was unveiled by a physician, who determined to trace back the girl's history, and who after much trouble, discovered that at the age of nine she had been charitably taken by an old Protestant pastor, a great Hebrew scholar, in whose house she had lived till his death. On further inquiry it appeared to have been the old man's custom for years to walk up and down a passage of his house into which the kitchen opened, and to read to himself in a loud voice out of his books. The books were ransacked and among them were found several of the Greek and Latin Fathers, together with a collection of Rabbinical writings. In these works so many of the passages taken down at the young woman's bedside were identified that there could be no reasonable doubt as to their source.

These principles of growth so forcibly set forth point with unmistakable clearness the way to social reconstruction; they constitute common grounds of procedure for all except a negligible minority of extreme eugenists and euthenists. What then are some of the implications involved in the frank acceptance of the doctrine that adult human beings are the result of a 'growing to' process and that the final result of such a process is a number of fixed habits of conduct which habits become the major premises of behavior?

First, society must curtail the procreative function, eliminating the future presence of infants which beyond a reasonable doubt are incapable of 'growing to' stable manhood. This means the elimination from Ohio alone of several thousand helpless dependents, absolute charges who carry not so much as a fraction of their own load in the world. Moreover this gains enormously in significance when such elimination would divert annually several millions of dollars to the 'growing to' process for infants relatively free from the handicap of incurable diseases. This by no means eliminates the 'hewer of wood and drawer of water' type, but it does signify the rejection of those who are unable to 'hew and draw' their own sustenance. Wisdom would seem to dictate the adoption of the eugenic program of elimination. The program is everywhere conservative, free from weak sentimentalism, impassionate and has the force of science behind it. Our mistaken notion of personal liberty has led us into the grievous error of permitting this problem to solve itself. Dr. Terman⁸ in a recent article sounds the following warning:

The problem is not one that can be left to its own solution, because there is no solution short of positive state action. The longer the menace

is neglected, the more threatening it becomes. In the last few decades the rate of reproduction among the socially fit has rapidly declined, but the feeble-minded continue to multiply at an undiminished rate. At the same time very beneficent social agencies and organized charities, necessary and humane as these are, nevertheless often contribute to the survival of individuals who would otherwise not be able to live and reproduce. The result is an ever-increasing proportion of socially unfit individuals in our state's population, and the problem can be met only by such an extension of the state's care of the feeble-minded, particularly of the high grades of feeble-minded, as will curtail the reproduction of defectives.

Second. The 'growing to' process does not admit the introduction of an unseen, transcendental power in the determination of human conduct. It is true that the brain may be organized, may 'grow to' the most absurd beliefs in anthropomorphism, if only the outward agents are favorable. Such beliefs, however, are habits and as such become vital determinants of behavior, but this must not be construed to mean that some superhuman agent steps in and makes decisions or choices by actually moving muscles. All beliefs are habits and their values in the final analysis must stand the test of character—do they or do they not sustain society? Measured by the pragmatic criterion alone, it would perhaps not be difficult to make out a case for our common species of revivals; especially is this true when it is remembered that most of the children of men have not paid the price to understand science and philosophy as they bear on this important question. Anthropomorphic habits, pierced by scientific and philosophic insight, as a rule, become inoperative. Certain of this class of habits are to my mind little short of pernicious. Reference is particularly drawn to the fatal notion that youth may sin with impunity and that at a more convenient hour a beneficent cleansing may be had for the asking. This is Rip Van Winkleism par excellence. "Nothing we ever do is, or ever can be, in strict scientific literalness, wiped out." Human behavior is a joint product of the interaction of inward and outward forces; the visible effects of such interaction are habitual modes of response. Could youth but realize that each experience leaves forever its unimaginable touch on the brain, that it is engraved there as with a steel stylus, they would give more heed to their conduct while in the plastic state. This simple incontestable truth does not seem to have seriously possessed many of our educational leaders, much less, therefore, the teachers who are in the more immediate presence of the brains of children. It seems to be asking too much of our educators and social workers to know even in a general way the architecture of the body, the system of peripheral and

⁸ "Feeble-minded Children in the Public Schools of California."

central wiring which is the very foundation of behavior so long as the weighty problem of making one box of chalk do the work of two or how to save an adult derelict remains unsolved.

Third. *What* the organism 'grows to,' *what* habits the adult finally possesses, is largely of society's making. We may fairly ask then what are some of the harmful outward social forces which leave their ineffaceable effects in the nervous system, which effects then become determinants of human behavior. No need to recount all of them! the list is as long as it is wearisome; then too we have lived in the midst of these baneful social agencies so long that the average human being becomes so completely adapted that he is as likely to be cognizant of them as he is of his own shortcomings. Need I mention the gun-toting scenes with their inflammable red setting, the scenes depicting man's inhuman treatment of womankind now so common in our melodramatic movies? The inevitable result of this form of brain 'branding' is practical enactment of similar scenes in real life. Corroboration of this point of view is not lacking in the courts of domestic relations and in juvenile delinquency. Not without reason do we find waves of crime with greater frequency and higher crests in our republic than in the more stable European lands. In one crime, perhaps the crime of crimes—the crime of war—Europe stands without a peer. The whole world bleeds and is in sorrow to-day because each European nation has insisted for many generations in organizing the brains of its citizens to look with suspicion, envy and even hatred upon the citizens of neighboring states. Fratricidal tendencies have thus been nurtured in the greenhouse of the brain and now these tendencies have ceased to be such and become actualities. Need I mention the flood of devitalizing, spineless, mushy reading which annually soaks the brains of thousands of young girls and effeminate boys and this at a time when the tissues are most plastic, most retentive? Great gobs of sobbing situations are written into the nerve cells, fibers and molecules and there maintained by 'nutritive substitution' as long as the body endures. Need I mention the eye and ear stimulations which emanate from the open saloon, from dens as varied as the tints and shades of spectral colors, from the line of talk common to our side-street pool rooms and dance halls? Think of this collection of social stimuli; think of them finding permanent lodgment in the molecules; think of society placing such a menu in the hands of juvenescent, romantic youth and he who runs may understand the genesis of a large fraction of irresponsible behavior in the world. Need I add to

this collection that fraction of the daily press which with zeal and devotion worthy of a nobler cause regales the public hunger with recitals of human weaknesses and frailties? How often do the Magdalenes, of high or low degree, occupy the headlines! As Thackeray so well says:

Who would meddle with dull virtue, humdrum sentiment, or stupid innocence, when vice, agreeable vice, is the only thing which the readers of romance care to hear. (In "Henry Esmond.")

When it is remembered that the daily sheet constitutes the main reading diet of a large percentage of families and that these families are important race-recruiting centers, then the brain organization effected by this medium assumes no inconsiderable importance. It is no psychologic dream or piece of sentimental fiction to charge three national tragedies to the malignant influence of an irresponsible press. The collective effect is far from social assassination. And now we find this invidious yellow creature invading England, where bloom the choicest flowers of modern journalism. Two classes of people escape this form of brain 'branding'—those who can not or do not read and those who, in the interest of mental hygiene, quarantine their homes against this modern plague. Need I mention the softening effect on character attending excessive indulgence in fictitious joys and sorrows enacted on the modern stage? James⁹ says,

Every time a resolve or a fine glow of feeling evaporates without becoming practical fruit it is worse than a chance lost; it works positively to hinder future resolutions and emotions from taking the normal path of discharge.

Weeping over fictitious situations may actually inhibit weeping over a real situation, so thoroughly does the brain 'grow to' the mode in which it is exercised.

The remedy would be never to suffer one's self to have an emotion . . . without expressing it afterward in *some* active way.

Heraclitus is said to have been perpetually weeping on account of the vices of mankind. Contrasting with Heraclitus is Democritus, the Laughing Philosopher, who is said to have made jests of the follies, sorrows and struggles of mankind. The modern Heraclitus, the Weeping Philosopher, fulfils his lachrymous duties most readily when human sorrows, struggles and follies are presented in fictitious personages. A Democritic attitude would be far less fatal and may be constructive

⁹ "Principles," Vol. 1, p. 125.

in its effect if the 'glow of emotion' aroused by a given fictitious situation leads to some response noble in character.

From the foregoing we may conclude that the problem of character formation, the development of responsible human behavior, demands (1) that society shall have a voice in determining with what kind of brain the human infant shall begin his struggle with the environment and (2) what outward agents shall determine the direction of its organization. Now, brain organization from this point of view covers what is commonly denominated as *will*. In the popular mind *will* is something free and indeterminate; from one point of view will is determinate, entirely a product of innate tendencies operating in an environment. In a somewhat narrow sense, will, in all likelihood, has no existence outside of acquired habits and the conflux of those habits. So-called strong wills are results of certain virile tendencies which, through the ministration of a favorable environment, have issued into habits which dominate all other tendencies to response. If environment fashions voluntary behavior out of general innate qualities, then man may be said to possess wills rather than will, the variety being co-ordinate with the more or less habituated responses. For this reason the same human being may reveal unflinching integrity and probity in meeting financial obligations and scandalously betray the municipality, state or the nation. The bundle of habits of which we are composed appears to be specific. Man's architecture is initially, *i. e.*, in infancy, singularly vague and general while in adulthood we find man more or less completely fashioned to act slavishly, irresistibly according to the mode of behavior which innate tendencies and environment have forged into habits. The belief in free will, a capricious, lawless, causeless, transcendental force, is itself a habit; the tenacity with which it is held is a fair measure of the extent to which the habit has become ingrained.

The 'growing to' process of which we have now so frequently spoken finds its terminus then in habits which constitute the very essence of behavior responsible or otherwise. Moreover it is not too sweeping a statement to say that the entire growth of human behavior comprises responses in varying degrees of habituation. No one, I think, would seriously maintain that our theologies are inherited; on the contrary they are acquired possessions like the multiplication table. Consequently we find the Baptist worshipping according to the appropriate baptismal tenets not because from the first he can not help doing so, as the cat pursues the mouse, but because his

brain has received the baptismal treatment. In other words, our beliefs are habits which probably differentiate but little with respect to values. It is not the purpose of this paper, however, to place values upon acquired responses; it is rather our purpose to trace the genesis, the ontogenetic evolution of behavior, whether responsible or irresponsible, efficient or inefficient. Upon society must rest the onus of a large percentage of irresponsible behavior; society pretty largely must answer for the crowded dockets of every link in the chain of our courts so long as 'soft pine' brains are permitted to multiply with abandonment and so long as sound brains run the open gauntlet of all forms of vice which are permitted to flourish with impunity. Each item on the docket is largely of society's own making and in the manner already indicated; each individual conviction is an indictment of society, in so far as each offender is in no wise responsible for the brain he possesses and only in part responsible for such organization, such 'branding' as it receives. In a very true sense society and more especially the intellectually *élite* is on trial.

By permissive negligence of society, an inmate of an asylum, or other detention institution, is more sinned against than sinning. The total institutional population is a fair inverse index of social health. Organized agencies for human alleviation is society's intuitive method of repentance.

Huxley observes that man has made no physical progress since the days of recorded history. To this, in view of recent European events, let us add the lack of certain aspects of moral progress. The remedy now at hand seems to rest on a detailed empiricism of modern science which, acting in conjunction with the speculative disciplines, offers the chief hope of man's physical and moral redemption. This remedy involves a frank acceptance of an *uncompromising* scientific puritanism. This newer puritanism will insist on the following: (a) Purging the human stock of strains congenitally without hope, (b) reduction of individual license by stiffening governmental control, (c) reconstruction of beliefs by making them consonant with the generally accepted tenets of modern science and (d) insurance of responsible behavior by organizing the brains of children through adequate control of environmental agencies.

In conclusion let it be said that here as elsewhere responsible behavior depends more upon sound morals than anything else and sound morals are sound habits due to sound parentage and a wholesome environment.

NATURAL SELECTION AND THE SURVIVAL OF THE FITTEST

By Professor I. W. HOWERTH

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IT is well known that Herbert Spencer, five years after the publication of Darwin's "Origin of Species," introduced the phrase "survival of the fittest" as an exact equivalent of "natural selection." He said:

The survival of the fittest which I have here sought to express in mechanical terms is that which Mr. Darwin has called "natural selection," or the preservation of favored races in the struggle for life.¹

It is also generally known, at least among scientific men, that Alfred Russel Wallace, co-discoverer with Darwin of the principle of natural selection, preferred Spencer's expression and urged upon Darwin the substitution of it for "Natural Selection," the ground of his preference being, not any difference in meaning of the two expressions, but the misconceptions that had arisen from Darwin's apparent personification of nature. He said, referring to Spencer's phrase:

This term is the plain expression of the fact; natural selection is a metaphorical expression of it and to a certain degree indirect and incorrect, since, even personifying nature, she does not so much select the special variations as exterminate the most unfavorable ones.²

And in the same letter from which the foregoing passage is quoted, he said,

Natural selection is, when understood, so necessary and self-evident a principle that it is a pity it should be in any way obscured; and it therefore seems to me that the free use of "survival of the fittest," which is a compact and accurate definition of it, would tend much to its being more widely accepted and prevent it being so much misrepresented and misunderstood.

Darwin replied:

I fully agree with all that you say on the advantages of Herbert Spencer's excellent expression "the survival of the fittest" . . . it is however a great objection to this term that it can not be used as a substantive governing a verb. I will use the term in my next book on domestic animals . . . the term natural selection has now been so largely used abroad and at home that I doubt whether it can be given up and with all its faults

¹ "Principles of Biology," Vol. I, Sec. I.: 65.

² "More Letters of Charles Darwin," Vol. I, p. 268.

I should be sorry to see the attempt made. Whether it will be rejected must now depend "on the survival of the fittest."³

He adopted the phrase, however, as an alternative expression of his own idea, and in the fifth and sixth editions of the "Origin of Species," as well as in some of his other books, it so appears. No objection was raised by him on the ground that it meant something different from "natural selection." Professor Huxley was not impressed, as was Wallace, by the superiority of Spencer's phrase. Writing of it in 1890 he said:

The unlucky substitution of "survival of the fittest" for "natural selection" has done much harm in consequence of the ambiguity of "fittest" which many take to mean "best" or "highest"—whereas natural selection may work towards degradation *vide epizoa*.⁴

But Huxley, no more than Wallace or Darwin, said anything to indicate that the two phrases are not identical in meaning and interchangeable, and they have thus been used by writers generally on the subject of evolution.

And yet there is a very important distinction between "natural selection" and "the survival of the fittest." Briefly it may be said that natural selection is a process while the survival of the fittest is a result; the one is a principle of limited application, the other a universal law.

Natural selection would obviously be powerless without something to select and something to reject and, although the selection is unconscious, it implies also a mode of selection. Natural selection, then, involves, first, a plurality of objects to select from, and these are presented in the organic world through the immense fertility of living things. In the second place, there must be variations in structure or function, or differences in the environment; and, in the third place, there must be a struggle for existence, at least in a metaphorical sense. Given these circumstances, the survival of the fittest naturally results. Of course if the selection is to have a cumulative effect, that is, if it is to be progressive or regressive, the element of heredity must also come into play. Natural selection, then, as a process, includes five elements, namely, the multiplication of chances, variation, struggle for existence, heredity, survival of the fittest. The survival of the fittest is the result of the operation of all the other factors. Another outcome is the elimination of the unfit, and it would be just as correct to identify natural selection with the elimination of the unfit as with the survival of the fittest.

³ *Op. cit.*, pp. 270-1.

⁴ "Life and Letters of Thomas H. Huxley," Vol. II., p. 284.

But this distinction between natural selection and the survival of the fittest, although valid, is not especially important. The whole is often named by a part, and to call the process of natural selection by its result is a permissible form of synecdoche. The same may not be said, however, of the distinction I am now about to point out, for it is both valid and important. It is the distinction previously referred to in the statement that natural selection is a principle while survival of the fittest is a law.

A law, in the scientific as distinguished from the legal sense, is a statement of the coexistence or sequence of phenomena as they are manifested to our senses. Observation and generalization are alone sufficient for the formulation of a law. Since a law expresses the uniform operation of a force, our knowledge of the uniformity enables us to control the direction of the force, and this is done by the application of some principle. The essential distinction between a law and a principle has been clearly brought out by Professor Lester F. Ward. He says:

A law is the general expression of the natural sequence of uniform phenomena. It states the fact that certain phenomena uniformly take place in a certain way. It takes no account of cause, but only of the order of events. A principle, on the contrary, deals wholly with the cause, or, perhaps more correctly, with the *manner*. It is the *modus operandi*. It has to do with the means or instrument by which the effects are produced. It is essentially an ablative conception. As principles deal with causes they must deal with forces. Gravitation, for example, is a force, but it operates in a regular way which we call the law of gravitation. Its various applications are principles or utilize principles. Thus the weight of water is a force, but the different kinds of water-wheels act on so many different principles—overshot, undershot, flutter, turbine, etc. The turbine wheel, for example, acts on the principle of reaction, according to Newton's third law of motion that action and reaction are equal and opposite. Other applications of the law of gravitation are those of weights, the balance, the pendulum, etc., all of which involve different principles. Water and steam expand by heat according to a certain law. This expansion of steam is a force which has been utilized by means of a number of mechanical principles—the piston, the cut-off, the governor, etc.⁵

Now, prior to the discovery of natural selection by Darwin and Wallace, Spencer, for one, had formulated the law of evolution. In his essay on "Progress, its Law and Cause," published in 1857, he showed that the law of organic progress consists in a change from the homogeneous to the heterogeneous, and that the law of organic progress is the law of all progress. The law of evolution, then, was recognized

⁵ Ward, "Pure Sociology," Pt. II., Ch. X., pp. 169-70.

and formulated before any one knew the principle of its operation. Spencer himself erroneously thought that, so far as organic evolution is concerned, it was functional modifications. Darwin and Wallace, however, explained the law through the discovery of its true principle. Thus Professor Ward remarks:

Evolution is a law, or takes place according to a law, the phenomena succeeding each other in a definite order of sequence. We observe successive phenomena and from them deduce or formulate the law. But natural selection is a principle. It teaches how the effects through observation are produced.⁶

Now it must be perfectly clear that, considered as a principle natural selection explains only a limited range of phenomena, namely, the phenomena of selection that are independent of conscious choice. It applies to germinal selection, physiological, sexual, and organic selection, but it does not apply to the phenomena due to the conscious agency of man in modifying the processes of nature. Here another principle applies, namely, artificial selection. But the law of the survival of the fittest applies to artificial selection as well as to natural selection. It is universal. The fittest always survive.

That this wider significance of the expression "survival of the fittest" is not generally appreciated is shown by the frequent assumption or declaration by writers on social questions that in modern society it is not the fit but the unfit which survive. Often in contrasting the operations of nature with those of human society it is asserted that the difference between the two lies in the fact that nature favors the fit while the opposite is true in society. In war, for instance, it is said that the unfit survive while the fittest are destroyed. But in war strength, courage, and the other fighting qualities are elements of unfitness for survival. Cowardice is at a premium. "He who fights and runs away will live to fight another day." Confusion arises from the ambiguity of the word "fit" or "fittest," as pointed out by Professor Huxley, fittest being mistaken for best. But always, in society as well as in nature, fittest means only best adapted to the prevailing conditions. Conditions, including man, determine the type. If conditions favor a higher type the fittest will be best and will survive, but if they favor a lower type the best will perish and the inferior will be preserved.

We have, then, in the "survival of the fittest" a universal law, a law which prevails in the organic world and in the social world, a law which is as rigid as the law of gravitation, and

⁶ *Op. cit.*

being thus invariable it indicates the possible control of social evolution through a recognition of the law. The necessary prerequisite of human improvement is the creation of conditions which favor a higher type of man and of society. Create these conditions and by the operation of this inexorable law the type favored by the conditions will come into existence and will survive. Progress is not, as Spencer says in the essay already referred to, a thing beyond our control. He says:

Progress is not an accident, not a thing within human control, but a beneficent necessity.

He is wrong on every point. Progress is an accident in so far as it takes place under the operation of natural selection. It is not a beneficent necessity, and just because it is subject to a great natural law it is within human control. If we learn enough about society to know what kinds of conditions are necessary to the survival of a higher type of society, and by intelligent effort bring these conditions into existence, the higher type will be ushered in and will survive. Knowledge is power with respect to social control exactly as knowledge is power with respect to the control of the mechanical forces.

RACE SUICIDE IN THE UNITED STATES III

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THE REASONS FOR THE HIGH BIRTH RATE IN THE COUNTRY

There is no need of dividing the rural population into classes in order to study the causes of the relatively high birth rate in the country. The great majority of people living in the country have incomes (counting what they use directly from the land) about the same as those in the comfortable class in the city. There are some people in the rural population who are really poor and there are a few who belong to the well-to-do and wealthy classes but these two extremes (not taking the negroes into account) comprise only a very small proportion of the whole. For this reason and also because I believe that all classes of people in the country, in spite of considerable differences in their incomes, think in much the same way regarding the size of their families, I shall speak of the farmer and non-farming rural population as belonging to a single class.

The women raised in the country have been trained to be home-makers. The changes which have been referred to above as unfitting many city girls to become good home-makers have not affected the country to any great extent. The country girl learns to help her mother about the home almost as soon as she can walk. There are numberless little tasks that she can do before and after school hours. If she happens to be an older child she gets training in caring for the younger children. She learns to make butter, care for the chickens, and to raise a garden as well as to cook and keep house. She never lacks for work about the home during vacations and after she has finished the country school. She grows up with the idea that her place in the world is to be a wife and mother. She never learns that the world offers almost numberless opportunities to women to do things outside the home. When the time comes for her to marry she knows what is expected of her and she is trained to the task.

The country woman who keeps house and does the work usually connected with housekeeping on the farm never needs to feel that she may be an economic hindrance to her husband

as many city women must. She knows, as her husband too often does not, that she is helping to make the farm pay. Her garden and chickens and butter and her daily economies constitute a positive contribution to the welfare of the family greater, in all probability, than that of many city women who work outside the home. A farm is commonly a partnership affair on its producing side, but as in most other industries the "boss" is able to distribute the product according to his desires rather than in accordance with the principles of justice.

The fact that the woman is such a direct economic asset on the farm probably accounts for the greater proportion of married women in the country and the earlier marriages there. Both of these things help to keep the birth rate in the country relatively high.

Children, too, are generally of economic value on the farm earlier than they are in the city. There are many kinds of tasks both for boys and girls on the farm which do not injure their health but which help to keep the work going smoothly. The bringing in of fuel, the care of calves and colts and pigs, errands to and from the fields, the assistance with the garden, all can be done by boys and girls, without injury to health, outside of school hours and during vacations. Besides the boy can even help with the field work by the time he is ten or twelve and be all the better for it, so long as he does little but drive a team hitched to light machinery. He can also help with the lighter parts of the heavier chores—the care of horses and cattle. The girl in addition to her chores outside the house can be of use to her mother in the house in a hundred ways and if not overworked will in no way be injured. I am fully aware that many country children are overworked and underplayed, but I do not believe that such a state of affairs is at all general. If it is, however, it only goes to prove that country people find children more economically valuable than I have supposed and are, therefore, more willing to have good-sized families.

In the country both boys and girls work at home by the side of their parents. Because of this they very soon learn that both father and mother are working for the same ends and that they are helping their parents to attain these ends. There is thus developed a unity of interest in the family in the country which is very often lacking in the family in the city. There is also less danger that the morals of the country children will be corrupted because of this close personal contact between parents and children while at work. I would not be understood

to say that, morally, all is as it should be in the country—far from it—but there is less chance that the average country boy will become utterly good-for-nothing than that the city boy will. I am quite convinced that the fact that parents and children spend much time working together in the country has a wholesome influence on the children in teaching them habits of steady application and thrift, while the fact that parents and children are together so little in the city has, in general, a demoralizing effect. This brings it about that parents in the country have less reason to fear for the future of their children and are therefore more willing to raise good-sized families.

Another way in which the unity of interest is developed in the family in the country is through the discussion of family affairs in the home. Most of the things that the farmer and his wife are interested in can be discussed with profit before the children. From the time the children are ten or eleven years old they can understand something of the problems of farm management and household management and they are also interested in what is going on in the neighborhood. In fact, the children very often have something to contribute that is of interest to the parents. Thus the whole family grows up within the same circle of interests and every member feels that he is included in any discussion or conversation that may arise. How different is the situation in the city! The business man comes home from the office or store with weighty matters on his mind and he finds it impossible to relieve himself by talking to the whole family, or even to his wife, because the thing absorbing his attention is highly technical. He finds his wife and children talking about neighborhood or school matters of which he knows little or nothing. So the family instead of being brought into closer unity by a mutual understanding of one another's interests is divided and the members may feel rather indifferent towards one another. Modern city life seems to me to have an increasing tendency to diversify the interests of the members of the family rather than to centralize them as rural life does.

Country life, therefore, makes it easier to keep alive interest in human beings than city life does. Definite personal interests—interest in wife and children, interest in school and church, interest in neighbors—take up a goodly share of the farmer's thought. He does not become engrossed with entirely impersonal matters as the city man is apt to. He must deal directly and humanly with people at almost every turn, while the city man deals more and more with *things* directly and

people only indirectly and technically. But even if the farmer becomes engrossed with things, *e. g.*, the extension of his acres, he yet hopes that he will have the children to help him till these new acres and to whom he can leave them, so that after all it is a family interest he is looking out for. I am quite certain that the more human and personal nature of the life of country people as compared with that of city people makes them willing to raise larger families.

Another reason for large families in the country is that it is easier to raise a good-sized family there than in the city aside from the fact country children early become an economic asset. The "barefoot boy with cheek of tan" is to be seen wherever one goes in the open country and usually his little sister is with him. The clothes may be soiled, the faces and hands dirty, but it is usually the "clean dirt" of the open country—the mud from the creek, the dust from the road or the stain of fruit and berries—not the foul slime from the gutter which one sees on the children in the poorer parts of our cities.

The country child always has a big playground at hand. In this playground are wagons and buggies, cultivators and plows, machinery and tools, cattle and horses, all of which call for careful attention and invite to manipulation. Many are the months and even years which the child can spend in playing with things which he will later want to use in his work.

If the children are not in the farm yard at play the mother may be quite sure that they are safe wherever they are. Besides, she knows all the neighbors' children and knows whether or not they are good companions.

The dressing of the children for school so that they will look respectable is not the trying task it often is in the city. Cleanliness and comfort are the two chief standards of respectability and they may be attained quite easily in the country. Colored dresses for the girls, with big aprons; overalls and blue shirts for the boys, with black stockings and heavy shoes for both, are sufficient for their requirements, and, for my own part, I think they look very well.

Furthermore, country children do not have the continual enticements to spend money that the city children have. They do not see the gaudy displays of toys and candies in the store windows on their way to and from school and, recently, the brilliant-colored lithographs of the "movies." If the country boy wants a sled he probably makes one, thus saving money and learning something useful. Country children learn to amuse

themselves rather than to ask papa for money to pay to be amused and this can not fail to relieve the country mother of much worry, because while amusing themselves around the home they are not very likely to get into much mischief. We must all agree, I think, that it costs less, in money, in work, and in worry, to rear a child in the country than in the city, and for this reason country people are more willing to rear them.

Moreover, the relatively secure economic position of the farmer makes him and his wife more willing to raise a good-sized family. The industrious farmer, either renter or owner, is practically certain of a fair living. Panics and hard times do not affect him as they do the industrial worker. Dissatisfaction of the capitalist manufacturers over a new tariff schedule does not throw the farmer out of a job nor render his living precarious, as it may the city worker. In fact the farmer is more or less immune from most of the disturbing conditions connected with modern industry. Of course, he occasionally loses a crop. But now-a-days when the farmer raises a number of different crops he very seldom has a total failure in all of them. For these reasons a farmer does not need to worry whether he will be able to feed and clothe his family, as many men in the city do. He can be practically certain that he will be able to meet the ordinary exigencies of life without a great deal of hardship to himself and his family. Because of this feeling of security of position the farmer has less reason than the city man to feel that he is giving irredeemable hostages to fortune when he has a large family.

We have seen that in the city many people limit their families because they feel they can not otherwise give their children the best opportunities. This motive to family limitation has very little influence in the country. The farmer generally regards his duty to the child as fulfilled if he allows him to complete the country school. He is quite sure that the boy who amounts to anything can shift for himself if he has a common-school education and has learned habits of steady application.

In the environment of the country most farmers come to believe that the schooling which was good enough for them is good enough for their children. They make no plans for the better education of their children which involve saving and preparing years ahead. This is not because the farmer does not want his boy and girl to have as good opportunities as other boys and girls, but rather because the only opportunities he

knows about are on the land and he does not see how an expensive education can help the boy to raise better crops. The average farmer little realizes how many opportunities are open to the young man with a good education which are closed to the one with only a common-school training because he knows little of modern city conditions. Therefore the farmer finds no reason to limit his family in the hope that he may thereby be able to give the smaller number of children an expensive training for their life work.

In the past, too, the farmer has known that there were good opportunities farther west if his family was too big to settle on the home place, and so he felt little anxiety over the future of his children. Even when the boy prefers to go to the city rather than to go west the farmer feels little doubt about his ability to compete with the city boy. He firmly believes that his boy can take care of himself wherever he may go. He also knows that the boy who works at home until he is twenty or more years of age owes him little economically for his "keep" and he does not feel that either his situation or the future situation of the boy would be much changed by rearing only a small family.

CONCLUSION

After this survey of the proportion of children to women in the different political units of the country and a study of the motives governing the birth rate in the different classes it may be well to ask: What conclusions can we draw regarding the conditions which, in general, favor good-sized families? and what is the outlook for the growth of our population in the near future?

In answer to the first question it seems to me the facts indicate that what may be called *frontier conditions* favor the rearing of good-sized families. By *frontier conditions* I mean not only pioneer conditions which exist when people are taking possession of new land, but all conditions in which people are accustomed to feel that there are good opportunities, easily available to their children—opportunities which require little if any special training in order to enable the children to do as well as their parents. Thus frontier conditions may exist even in the city.

Many poor immigrants in the cities feel that children should be and can be made economically valuable at an early age and with very little outlay on their part. That is, the standards of living are low, children are given comparatively little care, and they need no special training to get what seems to their par-

ents pretty good wages at some unskilled work. Thus they can contribute to the family income at a relatively early age and they can shift for themselves and do as well as their parents when the parents can no longer induce them to help to care for the rest of the family. I should consider some of the cities in the eastern and southern parts of the country, where there are many occupations open to children, as having more of frontier conditions than some of the cities in the middle west and west where there are very few industries in which children can be used with profit, *e. g.*, the manufacturing cities of New England would represent the former type, while Indianapolis, Kansas City, Denver and Los Angeles would represent the latter type. The rather high proportion of children in the urban population of some of the southern states may also be partly due to the frontier conditions in southern industry.

In the rural population, also, we find frontier conditions playing their part. States like Ohio and Indiana, in which agriculture is highly developed and is in a flourishing condition, but which were settled relatively early in the last century, have a smaller proportion of children than the newer states (except California). Abundance of land has meant open opportunity to the farmer's children. Even yet there is considerable opportunity on the land for those trained to make use of it. There can be little doubt that the farmer's children are the best prepared to take advantage of such opportunities as do exist. In the south there is still much land to be obtained cheaply and on reasonable terms. I have before me some booklets prepared by states and railroad companies interested in getting northerners to settle in the south. If only a third of the claims made by these people are true, the south is awaiting rediscovery at the present time. There is no doubt in my mind that the very large proportion of children in the rural districts of the southern and southwestern states is very largely due to the good opportunities for children to strike out for themselves at a relatively early age and do as well as their parents. We should always bear in mind, however, that where frontier conditions exist there is generally little knowledge of the means of voluntarily limiting the family. This is one factor, no doubt, in helping to keep the birth rate relatively high. But where the birth rate is high and frontier conditions do not exist—where opportunities for children are lacking—the death rate is usually so high that the proportion of children to women is rather low.

THE OUTLOOK FOR THE FUTURE

With the passing away of frontier conditions in the rural districts there is little doubt that the birth rate of the rural population will fall. It would not be at all surprising if the next census year would find several more of the great agricultural states of the middle west with about the proportion of children to women that Ohio and Indiana now have. And a few more decades will probably see the same movement in the whole of our rural population. But for the reasons given above in discussing the present high proportion of children to women in the country, I believe that the rural districts will always produce and rear more children than the cities.

The country is the natural place to raise children. Here they have opportunities for development and self-expression which I doubt ever being equalled by the cities with the best of playgrounds and schools. Besides, it will always be easier on the parents to raise children in the country than in the city. The care, the work, the worry and the expense of a child are less in the country than in the city and are likely to be so always. Even when the country gives the child much better educational opportunities than it now does this will still be true. It seems to me, therefore, that the country will continue to contribute the largest increment to the next generation by natural increase. I can see no danger of the newer immigrant stock "swamping" the older stock by natural increase so long as the newer immigrants remain city dwellers. There seems to be little chance that they will ever go to the rural districts in very large numbers. It might easily happen, however, that as the birth rate in the country becomes lower the newer immigrants would come to us in such large numbers, if unrestricted, that they would form the larger part of the increment to our population and in this way would become an increasing proportion of the whole.

It appears, then, supposing immigration should be effectually restricted, that the rural population is quite likely to continue to contribute the largest increment to our population, that the poor people in the cities will contribute the next largest, that the comfortable class follows next with almost the same rate of increase as the poor class and that the well-to-do and wealthy classes probably do not reproduce themselves. In the future the birth rate of the poor class is quite likely to fall as its members learn to restrict the size of their families, but the rate of natural increase will not fall proportionally because the lower birth rate will be accompanied by a lower death rate.

The same thing is also likely to happen, although not in so pronounced a manner, in the comfortable class. But there is good reason to believe that both of these classes will continue to contribute to the population in about the same proportion as at present.

The really important question for us, then, is: Is it eugenically desirable that our population should continue to increase as at present (leaving aside the whole question of increase through immigration)? Are the people with best capacities increasing most rapidly and those with least ability least rapidly? Unfortunately we can not answer this question as definitely as we should all like to have it answered, but certain facts seem to stand out quite clearly when we turn our attention to this matter.

I think that most people who are acquainted with our rural population would agree that in general it is of good stock. Most of the people are hardy, energetic and of good habits. The average of ability is good. There are, of course, many degenerate families and neighborhoods in the country, but these embrace only a small proportion of the rural population. Moreover, it does not seem likely that the selective action of the cityward movement of population has seriously affected the general level of capacity of country people, except, perhaps, in some of the older states, *e. g.*, New England. Therefore, the rather rapid rate of increase of the rural population is eugenically a desirable thing, for it adds an increasing proportion of good sound stock to our population. It is a movement in our population which should be encouraged and which we hope will be maintained in the future.

The poor class in our cities, which is adding the second largest increment to our population, probably contains more undesirable stock than any other class. I do not mean that this class as a whole is undesirable, but merely that the proportion of people in it who are of less than average ability is larger than in any other class. Being poor is not *prima facie* evidence of lack of ability, but people who lack ability, who are indolent and generally good-for-nothing, are quite likely to drift into the poor class in the city. Some means should be found of separating the desirables from the undesirables. The former should be encouraged to rear fair-sized families and the latter should be prevented from having offspring. The general rate of increase of this class is not too high, but we should try to see to it that the really incompetent become wards of the state and are not allowed to contribute to the increase of this class.

The comfortable class in the city is of much the same general ability as the rural population, and its rate of increase is fair. It should be encouraged to keep up its present rate of increase, because it contributes a good average of ability to the population.

The well-to-do and wealthy classes have, in my judgment, a higher average of ability than any of the other classes and are not contributing anything to the natural increase of the nation. In the process of selection through competition, people of ability tend to rise out of the lower classes into the higher and thus the upper classes come to have a relatively high average of ability. The very fact that a person can adapt himself to the conditions of life demanded by the change from one class to another seems to me to be proof of more than average ability. Of course, we must remember that many people are born into these classes and have shown no personal qualities which would entitle them to membership. But, even so, ability is, in all probability, inherited as other qualities are and it is, therefore, inherently likely that the son of a father of good ability would have more native ability than the son of a father of only moderate ability.

I can see no proof that good ability is not inherited in the examples of children of good families who have gone to the bad which are so often cited in this connection. In many cases it is probably not lack of ability which causes them to go to the bad, but lack of proper training. Only too often the child of the upper classes is exempt from the discipline and training essential to develop good qualities of character. All the latest developments of the science of heredity seem to me to point to the conclusion that the capacities of the parents are transmitted to their offspring, either in the first generation or in more distant generations, with little or no change. Therefore, if it takes good ability, as a general thing, to get into the upper classes, this good ability should be transmitted to children. Members of the upper classes, as a whole, whether they have risen by their own efforts or were born into these classes, should have more than average ability.

It should be born in mind that we are considering the average of ability in these classes, for there are no doubt many individuals who are of very ordinary ability. The proportion of people who become members of these classes by the merest chance, without any effort or merit of their own (aside from those born into these classes), is considerable. Then, too, sometimes the qualities which make for success are not socially

desirable qualities. Ruthlessness, callousness, indomitable ambition, selfishness, greed and brute force often make for financial success. I presume that few people would be anxious to see such qualities propagated or would consider their possessors of a high type. But in spite of the presence of many people with undesirable qualities in the upper classes I believe that the average of ability in these classes is higher than that in other classes.

If it is true that there is a greater proportion of people of high ability in the upper classes than in any of the others it is a calamity that they do not have as large a rate of natural increase as other classes. As the situation now stands, there is much truth in the statement that a democracy is likely to lead to race depletion. Our country offers excellent opportunities for advancement to men and women of unusual ability, but it seems to be moving towards race depletion, because those who rise to the top scarcely propagate themselves, to say nothing of adding to the numbers of the population. There is considerable reason to think that some of the best ability in the nation is being used up and not replenished because the upper classes have such small families or no families at all.

We need people of courage and earnest purpose in the upper classes to take the lead in a simplification of the standards of living and to uphold eugenic ideals, ideals which will lead them to sacrifice some present pleasure and perhaps undergo some definite hardships in order to leave offspring well equipped by nature and by training to carry forward the world's work. And their offspring should be numerous enough not only to replace themselves, but to add a moderate increment to their numbers in each generation. It is not enough that two children should be born in a family in order to keep up the numbers of the class, to say nothing of increasing the numbers. I have estimated that from 3.5 to 4 children must be born to each married couple in the nation in order to keep up the numbers of the population. In the upper classes, where the death rate is low, it might appear that an average of 3 children would be sufficient to keep up their numbers. But when we take into account the facts that (1) late marriages from which not more than one or two children can be expected are common in these classes, (2) celibacy is greater here than in other classes, (3) necessarily sterile marriages are probably more numerous than in other classes, it seems doubtful whether the numbers of these classes can be maintained with less than 3.5 to 4 births in the normal family.

In order to have a fair rate of increase in these classes, then, there should be an average of about 4.5 to 5 children born in the normal family as conditions now are. If the death rate of this class is lowered the number of children needed would be somewhat less, but not much increase in the rate of growth can be expected from this source, as the death rate in this class is already quite low. Then, too, the development of eugenic ideals in the upper classes should make it unpopular for the man fitted to be a father to remain a bachelor simply because it is the easier life. If more members of the class undertake to do their full duty by the next generation there will be more normal families in proportion to the number of persons in these classes, so that the burden on each married couple will be somewhat lighter.

Our most serious population problem at the present time (leaving aside the question of immigration) is the problem of utilizing the ability of the upper classes in this generation and having it preserved in their offspring for coming generations. I have a very high opinion of the capacity of the people in the lower economic classes. I believe that there is much ability in these classes equal to that of the better quality in the upper classes, but the process of using up the talent of a man or woman in one generation can not go on indefinitely without tending to lower the level of national capacity.

We need to develop a pride of family and of achievement in the upper classes so that they will feel it a part of their achievement to rear children to carry forward their work. We do not want to see family pride become arrogant, we do not want family pride to be based solely upon the height of the ancestral tree, we want it to be based upon achievement making for a wholesome and refined national life. When we have family pride of this type we can not have too much of it. It will inspire anew in each generation lofty ideals of honor and service. It will lead to the rearing of families of moderate size and will dictate their training so that they will be a joy to their parents and a power in directing local and national life into ever higher channels.

CLIMATIC INFLUENCES ON AMERICAN ARCHITECTURE

By Dr. ANDREW H. PALMER

FELLOW, AMERICAN GEOGRAPHICAL SOCIETY

FROM time immemorial man has been interested in the weather, primarily because of its influence upon those things which support and sustain him—his field-crops, his fruit-trees and his cattle. Only within recent years, however, has a new emphasis been placed upon climate in that it has been studied from the point of view of its influence upon man himself. In approaching the element of climate as an influence on man, his immediate environment and his daily activities, a new and interesting vista is presented to view.

During the centuries when man was a wanderer on the face of the earth, he naturally found it to his advantage to remain in regions where the climate was hospitable. He did not long remain in inhospitable climates until he had learned to construct a shelter, and thus to provide an artificial climate, when that was needed. These shelters, crude and rudimentary at first, complex and variegated later, form in their evolution a parallel with the evolution of man himself. In fact, in the narrative of man's evolution, the chapter describing his domicile is not less important than those concerned with his literature and his art.

Additional centuries passed between the time man ceased to be a nomad and the time when he possessed a well-defined architecture. In the beginning, architecture was necessarily domestic, in that it was entirely concerned with a house as a dwelling-place. As civilization advanced, the field of architecture grew to embrace structures like the temple, the market-place and the coliseum. Moreover, races and periods developed systems peculiarly their own. As a result, we now recognize distinct features of architecture when we refer to the Gothic, the Romanesque, the Byzantine, the Egyptian, the Persian, or the Mohammedan. Since the beginning of the nineteenth century, however, we have a unique situation in that there is no universal or generally prevalent style. While this is true of the Old World generally, it is even more true of the New World.

We have no well-defined American architecture. Like many other things American, we can not speak of this in the singular. We have American climates and American architectures.

Numerous causes contribute to the great variety in building design in the United States. For a given type of building the more important considerations which determine the design are the natural environment and the building material available. Climate may properly be considered as a phase of the natural environment. As an influence in determining the design of large structures like hotels, office-buildings and apartment houses, climate is a subordinate consideration. Seattle office-buildings resemble those of New York, and San Francisco hotels are not greatly unlike those of Boston. In the domain of domestic architecture, however, that concerned with a detached building used as a dwelling-place, climate is a dominating influence. In the construction of our homes we have learned to adapt ourselves to our environment. Just as climate differs greatly in the various parts of the United States, so the type of home construction also differs. When design is left to the skilled architect rather than to a blundering mason or carpenter, results tell the tale. In this age of efficiency it pays to consult the specialist. Moreover, the technical-architect is in greater demand to-day than is the artist-architect. In home construction practical needs are more important than esthetic considerations, and comfort is preferred to display. Climate as a phase of natural environment determines the practical needs in no small measure. An enumeration of some of the climatic influences upon home design in the United States will be given in the following.

INDOOR AND OUTDOOR CLIMATES CONTRASTED

People live in houses partly because of the fact that there one can regulate the climate of his immediate environment. Indoor climate is therefore essentially artificial, as contrasted with outdoor climate. The advantages of such an artificial climate are principally those of agreeable temperatures having a small range, and shelter from precipitation (rain, snow, sleet, etc.), from wind and from the sun. But there are certain disadvantages not so easily recognized. Only a few will be mentioned at this point. Even in modern dwellings having the most improved ventilating systems, the air is not as well adapted for breathing purposes as is that in the open. Moreover, during the half-year when our homes are artificially heated the humidity of the air indoors is usually too low for

our needs. When out-door air is introduced into our houses through ventilation, and is then heated to a comfortable living temperature, its relative humidity is reduced unless water is added through evaporation. While dryness in the air is not of itself harmful, the individual passing quickly from air of moderately high relative humidity outdoors to relatively dry air indoors, or *vice versa*, is subjected to a greater change than the delicate membranes of his nose, throat and lungs can endure without injury. The result is nasal or bronchial catarrh. It is only a comparatively short time that the serious effects of deficient indoor humidity have been recognized, and thus far no device has been generally adopted to offset them. A fortune awaits the man who will invent and place upon the market a simple, inexpensive and unobtrusive humidifier. Thus far house plants and evaporating trays have proved partially effective in combating this evil. Other factors contribute to the unfavorable features of indoor climate, but those mentioned are the most important. Incidentally it may be stated that most of our rooms are kept too warm in winter. There seems to be a universal feeling that 70° F. is the correct temperature for the air in a living-room. But it has been shown repeatedly by various investigators that mental work is done to best advantage in temperatures nearer 60° F., and manual work at temperatures not much above 55° F. With the proper relative humidity, 60°–65° F. is a comfortable temperature for a living-room.

Contrasted with the artificial indoor climate, the outdoor natural climate presents many points of difference. As a result of modern scientific research it has already become a proverb that "no healthy organism is hurt by exposure to sunlight and the open air." Given proper clothing and freedom of movement, man can live out of doors over the larger part of the globe. One of the curious lessons taught by the Great War is the fact that throughout a large part of Europe man can live out of doors in winter as well as in summer. It is related that countless soldiers who formerly lived an in-door life have improved in health by spending a winter out of doors in the trenches. Modern cures for pulmonary tuberculosis are based largely upon the beneficial effects of out-door living. In Florida and in the Southwest, many people, both well and ill, live out of doors throughout the year. Moreover, few people "catch cold" while out of doors. The most frequent causes of colds are contaminated air, sudden temperature changes and draughts. Outside an enclosure the air is never contaminated,

and draughts out of doors are harmless to the person in good health.

CLIMATIC INFLUENCES ON AMERICAN HOME DESIGN

A large proportion of the American people now live in crowded conditions in the apartments and tenements of great cities. But the home which is generally considered the typical American home is that of a detached wooden, brick or concrete house, of five to ten rooms, two to three stories in height, surrounded by a yard containing lawn and garden, and situated in a small town or in the suburbs of a large city. Strictly from a climatic standpoint, wood for construction purposes has the



Courtesy of The National Builder.

A LOS ANGELES BUNGALOW. The veranda shown at the left of the picture serves as a living room which can be used throughout the year.

advantages of being a non-conductor of heat, and when painted is nonporous. However, it has the disadvantage of being insecure in a strong wind. Brick has all the advantages of wood, and is more secure in the time of storm. Concrete, the use of which is increasing rapidly from year to year, has the one serious disadvantage that it is porous, and admits moisture in humid climates. However, with the use of various preparations now on the market it can be made water-tight.

With reference to the size of the house, climate is considered by the architect because in winter it takes more fuel to heat a large house than a small one, while in summer a large house is kept cool more easily than a small one. For this reason the North Dakota cottage is usually small compared with



Courtesy of *The National Builder*.

A MODERN CONCRETE DWELLING IN EVANSTON, ILLINOIS. The sun-parlor shown in the foreground is on the south side of the building, and therefore receives the maximum possible amount of sunshine.

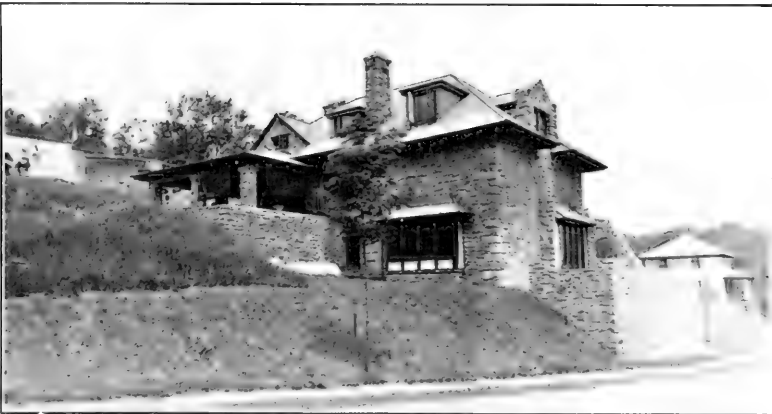
the Virginia mansion. The large manor-house of the South, having spacious, open rooms and wide hall-ways is well adapted to the long heated period. During the past decade the bungalow type of dwelling has become popular in the West. These are usually small, but one story in height, with the rooms so placed that they enclose an open courtyard. The man who first designed this last feature recognized the value of and the universal desire for life in the open. In southern California, where extremes of climate are unknown, the bungalow is little more than four screens, or side-walls, with a roof thrown across the top. Such bungalows, appropriately known as "canary cottages," answer every need for a habitation.

The thoughtful architect also considers climate in determining the height of the dwelling he is planning. Throughout most of the United States the summer half-year is a hot period. For this reason living-rooms and sleeping-rooms are not placed directly underneath the roof in the well-planned home. There is an open air-space above such rooms in the form of a second floor or attic. The cellar floor is usually below the surface of the ground outside, and since cool air is heavier than warm air the cellar is the coolest part of the home during the summer. In the modern dwelling the cellar is utilized for a summer study or workshop, whereas formerly it was little more than a store-room.

Even in planning the surroundings of a dwelling the architect now considers climate. The typical New England home is surrounded by shade-trees, is often vine-covered, and sometimes is invisible from the road but a few feet distant. As the foliage is absent in the winter, the desired sunshine is then secured, while in summer its shroud of verdure promotes coolness in the dwelling. In the Middle West, trees serve another useful purpose, in that they act as wind-breaks on the level, wind-swept prairies. Every one who has crossed Iowa has observed that a hundred or two hundred feet west of each farm-house is a tall row of trees, planted as close together as they will grow.

The exposure of the dwelling naturally suggests itself next. The climatic features the architect considers in planning the exposure of a contemplated structure are sunshine, wind and rain. Each of these factors deserves consideration.

Sunshine is the best natural germicide, both for the individual, as well as for his immediate environment. While the tanning of the skin by the sun, which some people strive so hard to secure at the sea-shore during the summer time, is of itself of little or no value, it is good evidence that the individual has spent some little time under healthful conditions. The sun helps him perhaps more than he realizes. Besides being a germicide, sunshine is also a nerve tonic. This is not true in tropical countries, but is true in an intermediate latitude like that of the United States. Moreover, sunshine promotes dryness, particularly when admitted into a building. In home design the ideals to be sought are sunshine which does not glare, and shade without draughts. Generally speaking,



Courtesy of The National Builder.

A DWELLING IN BUFFALO, NEW YORK, IN WHICH THE NATIVE LIMESTONE HAS BEEN UTILIZED TO GOOD ADVANTAGE. The wide veranda at the rear serves as a living room during the summer months.



Courtesy of *The National Builder*.

THE PHYSICIAN'S HOME SHOULD BE A MODEL OF HYGIENIC PERFECTION. Here is shown the home of a surgeon dentist which is well adapted as a combined home and office.

people admit too little sunshine into their homes. Window-curtains are too often lowered when they should be raised. It is less expensive and far more agreeable to replace faded house-furnishings with new ones occasionally than it is to pay doctors' bills. Residents of the West have a saner attitude in this respect than those of the East. In California it is an unpardonable sin to cut off the sunshine in a building. On the other hand, the Indiana novelist usually describes a home as a house with green shutters.

Wind and rain are climatic factors also to be considered by the architect. Throughout the greater part of the United States the prevailing winds are from the west. Northerly winds are cold, southerly winds are warm. The east winds, least frequent of all, are the rain-bearing winds. The undesirable winds are the cold and boisterous winds of the north and west. The desirable winds, warm and gentle, are from the south.

The climatic considerations are alone sufficiently important to determine the ideal exposure of the home. A southern exposure for the living-rooms is best because this gives a maximum of sunshine and a minimum of cold winds. In a hotel the south-facing rooms are in most frequent demand, for obvious reasons. If the living-rooms of a house can not conveniently be arranged to face the south, an eastern exposure is second-best. This gives the rooms the morning sunshine and eliminates the west and north winds. A disadvantage is the fact

that the rain usually descends from some easterly point. However, this is not a serious defect in the arrangement, as the total time of rainfall and the persistence of easterly winds is but a small fraction of the year as a whole. As a corollary to these conditions, it might be added that the rooms in which the least amount of time is spent, the dining-room for example, are most advantageously given a northern exposure.

Though anomalous, it is true that the proper exposure of chicken-coops was considered long before that of our homes. Poultrymen long ago built their hen-houses with a south exposure of glass and a northern wall unbroken by a single aperture. Only within a comparatively few years have we thought it important enough to plan our homes with equal care.

The question of exposure suggests consideration of the arrangement of our cities themselves. Every one who has traveled extensively in the United States has observed that the best residence portions of our cities are to the west or the north of the business and manufacturing centers, rarely to the east or south. The aristocratic portion of the city is usually the west or the north side, while the east side has become synonymous with the home of the poor, the "cheap-side." Congested cities and those located on water-fronts do not show this fact conspicuously, but the rule is true of American cities generally. Climatic considerations form but one group of many groups which determine the arrangement of a city. But the east side



Courtesy of The National Builder.

THE COURT YARD AT THE REAR OF A PASADENA, CALIFORNIA, BUNGALOW. It is readily apparent why the resident of this dwelling has no doctor's bills to pay. Note the open-air sleeping-porches shown at the left of the picture.

of the city has become the side of lowest real estate value partly because to it the prevailing winds carry the smoke, the dust, the odors and various other excreta of commercial enterprises.

LOCAL CLIMATIC INFLUENCES

The observing traveler can not help but notice local climatic influences on vegetation, on the clothing and the customs of the natives, and, the only matter which concerns us in this discussion, on the architecture. These peculiarities are often observable from a car-window, and may serve to break the monotony of a transcontinental journey. Some conspicuous adaptations of architecture to climate will be enumerated in the following.

Sleeping-porches are a comparatively recent invention. Their increasing use bears witness to the fact that we are wisely



Courtesy of The National Builder.

A DWELLING OF A DESIGN FREQUENTLY ENCOUNTERED IN BOSTON AND IN OTHER NEW ENGLAND CITIES. Well adapted to the extremes and the frequent changes of New England climate.

paying more and more attention to hygiene. For climatic reasons the sleeping-porch can be used with comfort only during the summer-time in the northern portion of the United States, but elsewhere it can be used to advantage throughout the year. In Los Angeles it is difficult to sell or to rent a dwelling that does not have at least one sleeping-porch.

The screened veranda is also becoming common. It too can be used only during a portion of the year in a large part of the country. But even a limited use serves to satisfy that longing for life in the open. Screens on veranda or window are conspicuously absent on the Pacific Coast, as climatic conditions do not permit the propagation of flies and mosquitoes in large quantities, so screens are unnecessary.

In the Middle West there has been developed an architectural feature known as the summer-kitchen. This is simply a one-room building detached from and immediately to the rear of the dwelling. During midsummer months of almost unbearable heat the family cooking and laundry-work are done in this detached building in order that the dwelling proper may be spared the addition of avoidable heat and odor.

In cities along the Gulf of Mexico in general, and in New Orleans in particular, projecting balconies on the second and third floors are conspicuous. Moreover, the living-rooms of many homes are also on the second or third floors. The climatic significance of these considerations lies in the fact that the ground floor is too damp for comfort and for health. Dryness of floor and air are worth the exertion of stair-climbing. New Orleans is sometimes referred to as the most conservative of American cities. In this particular respect her conservation appears to be well founded on an obvious scientific truth.

The use of storm-doors and storm-windows is good evidence that severe weather is occasionally experienced. Throughout most of the Middle West and in the northern portion of the Atlantic coast region the winters are so severe that dwellings could not be kept comfortably warm without the use of storm-doors and storm-windows, and, moreover, their use conserves fuel consumption. Along the Great Lakes, as well as along the sea-coast, double windows serve the additional purpose of resisting destructive winds which are sufficiently strong to blow in a single thickness of window-glass. In Minnesota and the Dakotas, where temperatures of twenty to forty degrees below zero occur every winter, the lower portions of the humbler cottages are enclosed with tar-paper or burlap each autumn in order that artificial heat may be retained.

The use of tall smoke-stacks on factories shows climatic influences indirectly. By the use of great height in the chimney an accelerated draught is secured for the fire-box, and, moreover, the gaseous waste-products are expelled sufficiently high in the atmosphere to secure their harmless dispersal. The



Photograph by Fred Rath.

A MODERN DWELLING IN A WINTER SETTING.

tallest smoke-stacks in the United States are those in connection with smelters, where poisonous fumes are thus expelled to best advantage. Furthermore, in planning groups of buildings like universities and civic centers the position of the heating-plant should be determined in large measure by the prevailing direction of the wind. The need for considering this matter in the planning is obvious.



Photograph by Fred Rath.

A JANUARY SCENE IN A VILLAGE LOCATED IN THE HIGH SIERRA NEVADA MOUNTAINS.
The need of warm dwellings in such an environment is apparent.

CONDITIONS IN CALIFORNIA

California is the climatologist's paradise. Here within a comparatively limited region one can find an epitome of all the various climates of the United States, besides some climates peculiarly her own. Extremes of climate as well as diminished ranges are exemplified in different parts of this state of infinite variety. For these reasons climatic influences on architecture are readily apparent there. A few of these will be mentioned.

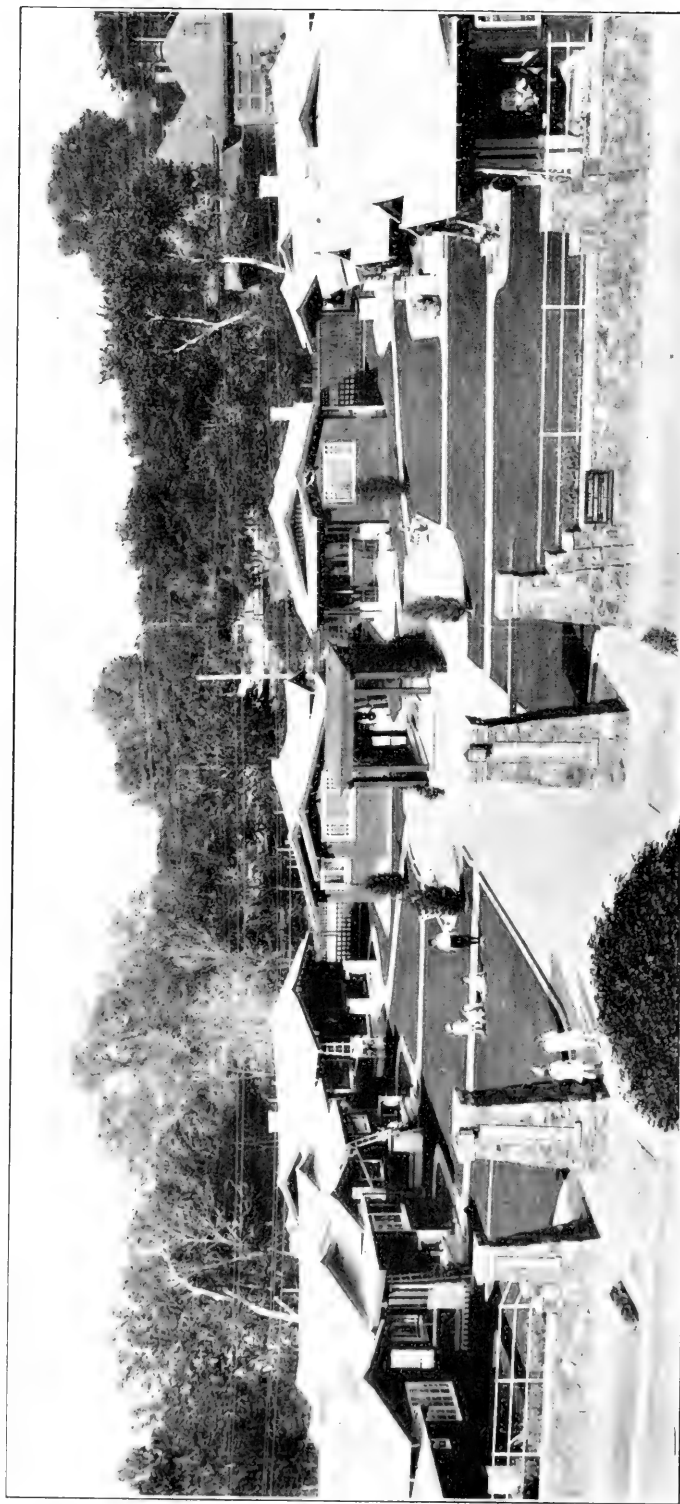
The portion of California which is most densely settled and which is best known in the east has mild temperatures, meager rainfall and few extreme weather conditions. It is therefore a



Photograph by Fred Rath.

A COTTAGE SHROUDED IN A MANTLE OF SNOW. Snow is a poor conductor of heat, and a good protector from winds. Such a dwelling may therefore be kept warm in spite of its frigid appearance.

land of the out-doors, and life is largely in the open. At the recent Expositions at San Francisco and San Diego many of the exhibits were out of doors. Art objects of great value were exhibited in the open. The flower-markets of San Francisco are on the sidewalk in winter as well as in summer, and band-concerts are given on Sundays throughout the year in Golden Gate Park. The Greek Theater of the University of California has no roof. The ventilation of moving-picture theatres, a troublesome problem in a large part of the United States, needs no solution in southern California, where there are only a few nights in a whole year when such pictures can not be viewed under starry skies. The waiting-rooms of railway stations are also in the open, with only a roof for protection from sun and



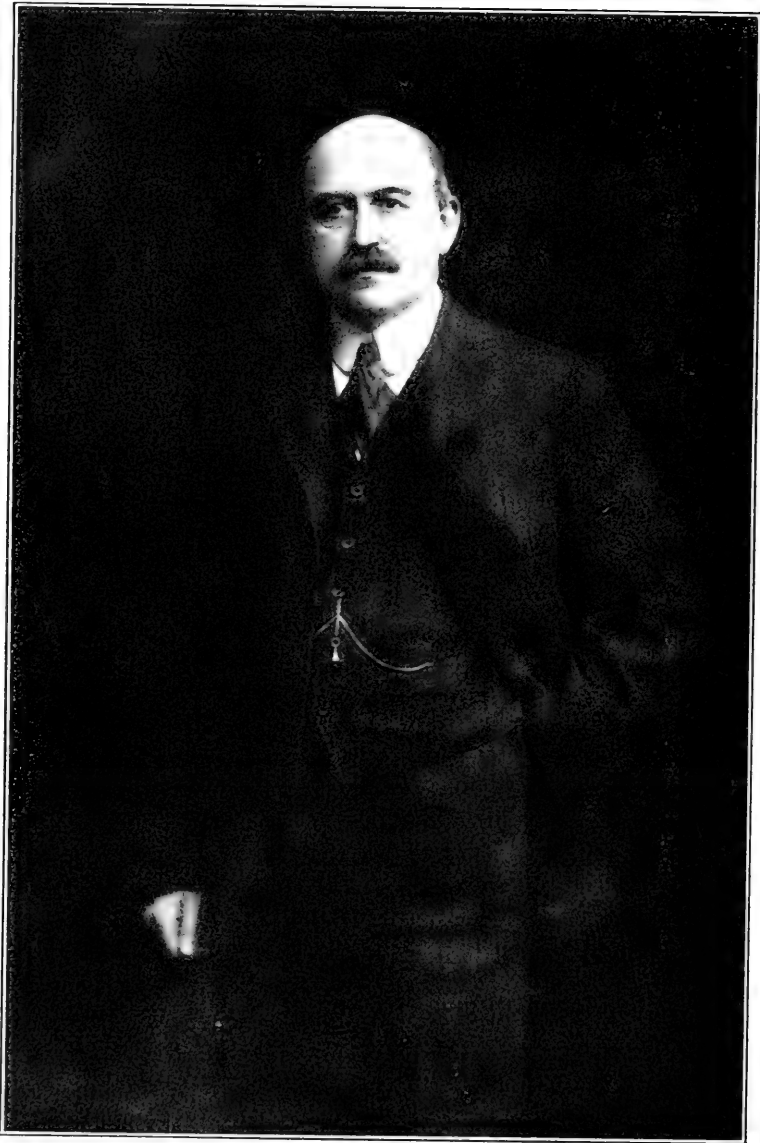
THE BUNGALOW COLONY IDEA IS INCREASING IN POPULARITY IN THE WEST. Is it any wonder that the death-rate among residents of such a colony is but a small fraction of that which obtains in the tenements along Hester Street, New York, or along Blackhawk Street, Chicago, where more than 2,000 persons live within a single block?

Courtesy of The National Builder.

from the occasional shower. Where the sunshine is oppressive, a double roof is constructed so that the air space thus provided may insure cool temperatures in the shade beneath.

CONCLUSION

In this age of efficiency, greater attention is being paid to details than ever before. It appears to be a trait of human nature to consider material and external things first, and personal and internal things last. From the point of view of climate we have long studied the relations of weather to crops. Only recently have we considered its relation to man himself. One phase of the new interest in climatic influences on man himself is that evident in the increased attention being paid in domestic architecture to weather and climate as a condition of environment. The careful architect can not and does not disregard the weather records in planning the most humble bungalow. Considerations of comfort demand that the type of construction, the arrangement of the rooms, the exposure and the heating system, should be adapted to the climate of the region concerned. Considerations of safety demand that the construction shall be made to withstand extremes greater than any which appear in the recent records. Just how large a margin of safety should be provided for is a complex problem, and one whose ultimate solution rests upon an extended weather record for the particular vicinity considered. Matters like these have influenced the design of the home, which, like many other things, has evolved rapidly of late, and is even now in a transition stage. In the well-planned modern home the living-rooms face the south to secure a maximum of sunshine and a minimum of cold and boisterous winds, while the least used rooms are placed to the north, as that is the least desirable exposure, climatically considered. The top-most room, formerly a dusty attic or store-room, has become a sun-parlor. The basement, formerly the laundry or cellar, has become the summer study or work-shop. By a wise dispensation of nature, a comfortable environment is usually a hygienic environment also. Collectively, man has gained much by ceasing to be a nomad. Individually, men are happiest when they live in their own homes. Natural environment determines in large measure the nature of that domicile. Weather conditions are now considered by the conscientious architect in planning the construction of such a dwelling, and the artificial climate which is to be created within it.



WILLIAM BULLOCK CLARK.

Professor of geology in the Johns Hopkins University, eminent for his contributions to geology, who died on July 27 at the age of fifty-seven years.

THE PROGRESS OF SCIENCE

THE NATIONAL RESEARCH COUNCIL AND THE WAR

As has been described in *THE SCIENTIFIC MONTHLY*, the National Research Council was organized under the auspices of the National Academy of Sciences at the request of the President of the United States to promote scientific research and especially to cooperate with the government in the present emergency. It has now become a department of the National Defence Council, dealing with the organization of science and research as affected by the war.

As our government through its scientific departments devotes more attention to scientific work than any other nation, they would be the natural agencies to take charge of the applications of science to the national welfare in the present emergency. It may, however, be that better results can be secured by calling on the scientific men of the whole nation who are the best fitted for such service. This was indeed the plan of the government in making the National Academy of Sciences its scientific adviser.

Dr. George E. Hale, director of the Mount Wilson Solar Observatory of the Carnegie Institution, is chairman of the National Research Council, and gave his entire time to the work at Washington until his recent return to California; Dr. Robert A. Millikan, professor of physics in the University of Chicago, now represents the National Research Council, in general charge of the scientific questions referred to it. Other scientific men who are devoting their time to national service in Washington are: Dr. C. E. Mendenhall, professor of physics in the University of Wisconsin, who is in charge of the development of instruments used in connection with aeroplanes; Dr. Raymond Pearl, of the University

of Maine, chairman of the agricultural committee; Dr. Alonzo E. Taylor, of the University of Pennsylvania, chairman of the food committee; Dr. Marston T. Bogert, of Columbia University, chairman of the chemistry committee; Dr. Victor C. Vaughan, of the University of Michigan, chairman of the committee on medicine and hygiene; Professor Robert M. Yerkes, who has just accepted a call to the University of Minnesota, chairman of the psychology committee.

Among scientific men in Washington who are taking an active part in the work of the National Research Council are Dr. Charles D. Walcott, secretary of the Smithsonian Institution; Dr. S. W. Stratton, director of the Bureau of Standards, and Dr. Van H. Manning, chief of the Bureau of Mines. Scientific men from England, France and Italy have been in Washington in consultation with the members of the National Research Council.

Members of the foreign service committee of the council, who have been in France and England for a period of two or three months, have returned to the United States and have brought with them much valuable information relative to the organization and development of scientific activities in connection with the war. A few members of the committee have remained in France to continue their observations and investigations, under special detail. Formal reports have been submitted to the council, through its executive and military committees, relating to the observations and experiences of the members of this committee, in connection with which recommendations for cooperative investigations in this country are made.

The government has so far made little or no provision to pay the cost of this scientific work, most men of



A TREE FERN (*Cibotium menziesii*) NEAR THE VOLCANO KILAUEA ON THE ISLAND OF HAWAII. The tree ferns are conspicuous elements in the Hawaiian landscape in the wet areas.

science having given their services without salary. The work of the council has been supported by private gifts, including an appropriation of \$50,000 from the Carnegie Corporation. Some scientific men have, however, enlisted as officers in the army, and the passage of the food bill and other measures will

doubtless permit the government to support and control the scientific work being done on its behalf.

EXPLORATIONS IN THE HAWAIIAN ISLANDS

PROFESSOR A. S. HITCHCOCK, systematic agrostologist, U. S. Department of Agriculture, has spent about

six months in the Hawaiian Islands, collecting and studying the flora, especially the grasses. He was assisted by his son, A. E. Hitchcock. The six larger islands of the group were visited.

The islands are of volcanic origin and are mainly composed of lava. Kauai, geologically the oldest island, shows the greatest effect of erosion, its deep canyons rivaling the beauty of the Grand Canyon of Colorado. Hawaii, the youngest island geologically, shows a great variety of recent lava. The active volcano Kilauea (4,000 feet) with its pit of boiling lava, is on Hawaii, while Haleakala, said to be the largest crater in the world, is on Maui, the second largest island of the group.

The flora of the islands is interesting because of its diversity and peculiarity. The diversity is due to the extremes of altitude and of moisture. All the islands are mountainous. Hawaii, the largest island of the group, includes the two high peaks Mauna Kea, 13,825 feet, and Mauna Loa, 13,675 feet. Vegetation on these peaks reaches to about

10,000 feet altitude, above which there is much snow in winter and snow banks persist throughout the year. The trade winds deposit their moisture on the eastern slopes of the mountains, thus giving rise to rain forests, while on the lee sides of the islands the conditions approach aridity. The rainfall on Waialeale, the highest peak of Kauai, is as much as 600 inches per annum, while on the western sides of the islands it may be less than 15 inches.

In Honolulu there is a marvelous variety of exotic trees and shrubs, including many kinds of palms. There is an especially rich collection of plants in the Hillebrand Garden, formerly owned by the author of Hillebrand's "Flora of the Hawaiian Islands." Scores of varieties of *Hibiscus* line the streets as hedge plants. The monkey pod or saman tree (*Pithecolobium saman*) is a beautiful round-topped shade tree.

One of the introduced trees of great economic importance is the algaroba tree, or kiae, as the Hawaiians call it. It is found in a belt on the low-lands along the shores



NIGHTBLOOMING CEREUS. Growing over the wall in front of Punahou College, Honolulu. Strikingly beautiful when in flower.

of all the islands and occupies the soil almost to the exclusion of other plants. The pods are very nutritious and are eagerly eaten by all kinds of stock. Its flowers furnish an excellent quality of honey. The Molokai ranch alone produces 150 to 200 tons of strained honey per year. The prickly pear cactus (a species going under the name of *Opuntia tuna*) has become extensively naturalized in the dryer portions of all the islands. Ranchmen utilize this for feed when other kinds become scarce, the cattle eating the succulent joints in spite of the thorns. Two introduced shrubs now occupying extensive areas have become great pests. These are guava, whose fruit furnishes the delicious guava jelly, and lantana, with clusters of handsome parti-colored flowers. One of the important indigenous trees is the koa. This produces a valuable wood much used in cabinet making, now becoming well known through its use for making ukuleles.

Among the peculiar plants of the islands is the silver-sword, a strikingly beautiful composite with glistening silvery leaves, which grows only on the slopes of cinder cones in the crater of Haleakala and in a few very limited localities on Hawaii. The family Lobeliaceæ is represented by about 100 species belonging to 6 genera. The numerous arborescent or tree-like species are very peculiar and characteristic. Many of them form slender trunks like small palms, crowned with a large cluster of long narrow leaves. The trunks of some species are as much as 30 or 40 feet high and the large bright-colored flowers are sometimes remarkably beautiful.

The ferns are numerous and in the moist areas are often a dominating feature of the flora. Three species of tree ferns are found on the islands, and in some places form extensive forests. These plants pro-

duce at the base of the stipe, a great ball of brownish-yellow wool called pulu by the natives and used by them for stuffing pillows and mattresses.

A peculiar ecological feature of the islands is the open bogs found upon many of the summits of the high mountain ridges in the regions of heavy rainfall. Many species form more or less hemispherical tussocks which rise above the general level of the bog. A showy lobelia with numerous large cream-colored flowers as much as three and one half inches long, peculiar violets, and a sundew are found there. These boggy areas are devoid of trees and sometimes occupy rather extensive areas, the one on Mt. Wai-aleale covering several square miles.

SCIENTIFIC ITEMS

WE record with regret the death of Charles Horton Peck, former state botanist of New York; Edward Randolph Taylor, the American industrial chemist; of William Wallace Tooker, an authority on Indian archeology, and Robert Bell, formerly chief geologist of the Geological Survey of Canada.

THE Albert medal of the Royal Society of Arts for the current year has been awarded to Orville Wright, "in recognition of the value of the contributions of Wilbur and Orville Wright to the solution of the problem of mechanical flight." The report of the council says: "The largest share in the honor of having invented the aeroplane must always be given to the two brothers, Wilbur and Orville Wright."

M. ERNEST SOLVAY, the distinguished Belgian industrial chemist, who has made large gifts for the endowment of chemical and physical research, has been elected a corresponding member of the Paris Academy of Sciences in the place of the late Sir Henry Roscoe.

THE SCIENTIFIC MONTHLY

OCTOBER, 1917

APPLICATIONS OF SCIENCE TO WARFARE IN FRANCE

By GEORGE K. BURGESS, Sc.D.,

PHYSICIST AND CHIEF OF DIVISION OF METALLURGY, BUREAU OF STANDARDS

THE chemists say this is the chemists' war, the engineers claim it as theirs, while a distinguished French physicist calls the struggle "a grandiose physical phenomenon," and the medical and surgical fraternity demonstrate their prevention from epidemics and rendering possible the return to the front some three fourths or more of all invalided and wounded has made the continuance of trench warfare possible.

Verdun has been named "the metallurgical battle" and also "the battle of the trucks," referring in the first case to the importance of the iron ore deposits of the Briey region located a few miles to the northeast and in the second to the vast numbers of automobile trucks employed by the French on the only highway open at the outbreak of the battle, namely, that connecting Bar-le-Duc with Verdun.

The meteorologist is listened to with attention by the Great Headquarters, as was the astrologer of yore, before an extensive offensive is undertaken; and the geologist is consulted for information as to where to halt and dig in, where shelters may be safely built and as to the probability of underground waters. Even the astronomer's services are considered of great importance, for example, in the preparation of new artillery tables and maps, the improvement and invention of instruments, which differ but slightly in principle, however much they may differ in the nature of their use, from those with which he is familiar. Again, the statistician is a most valuable person when an offensive is being planned. Also the mathematician France, at least, has found indispensable, for in the person of M. Painlevé he sits at the head of them all as minister of war, whose civil, technical staff is largely made up of eminent mem-

bers of the same profession. Is this then a mathematicians' war?

In truth, chemistry, physics, hygiene, mathematics, engineering, geography and geodesy, metallurgy, geology, bacteriology, meteorology, or pretty much the whole curriculum of physical and natural sciences, and their applications, are each of them fundamentally essential in modern warfare, some of course more apparently so than others, but almost none could be spared and the war carried on successfully.

Two most important corollaries immediately suggest themselves:

First, the war can not be successfully prosecuted if there is lacking any of the necessary raw materials including chemical, physical and metallurgical supplies such as nitrates, optical glass, coal and steel, to name but a few. The operations of modern warfare are so complex and interrelated that the want of crucial supplies in one domain may seriously hamper all; hence the phenomenon of which there are instances innumerable, of intensive scientific research in the development of substitutes as one or another essential material becomes scarce. There is many an interesting memoir in this field awaiting the end of the struggle to see the light.

Second, modern warfare can be waged successfully only by the proper organization of these diverse scientific elements in addition to, and coordinated with or incorporated in, the military establishments.

In a completely mobilized country, such as France, it is essential that each man in the community, which is nearly identical with the military establishment, be assigned to the task for which he is best fitted—or there must be scientific organization and management to secure the country's greatest possible efficiency.

What is this organization? how and to what extent are the sciences used in warfare? and how are the scientific men mobilized or otherwise made use of? The complete answers to such questions can not be expected in so short a space.

It was the writer's privilege to be one of a scientific mission sent abroad by the National Research Council, immediately after America's entry into the war, for the purpose, among others, of finding answers to the above questions. A brief statement of some of the impressions gained during a three months stay in England and France may not be without interest. Our mission had extraordinary if not unique opportunities for close observation of all the aspects of science in warfare, not only

from many interviews, visits to laboratories, manufacturing plants, and technical ministerial bureaus, but also from inspection at the fronts of the French and British armies of the organization, application and actual operation of the scientific and technical services, all of which were shown and explained to the most minute detail.

The most striking impression brought home is one of unity of purpose, perfect adaptation and coordination of the several branches, a harmonious whole, in fact, made up of separate and often highly intricate parts constituting an organization in which all the sciences and their applications blend into one, which is focused by the admirably trained technical and staff officers on the sole object of destroying the enemy. The French traits of individuality, initiative, and self-reliance are, however, in no sense lessened or dulled by this cooperation.

What are some of the component parts of this unity in scientific warfare? We shall mention but a few in illustration of the whole. Let us first consider examples of the applications of physics to warfare, some of which owe much of their efficacy to the relative immobility of the front.

Of all the branches of this science the one that had in recent years been lagging behind the others and to whose development the least attention was being paid, was acoustics; yet it is not an exaggeration to say that the application of the principles of acoustics, or sound, is of the greatest importance at the front.

One of the most highly developed is the location of enemy guns, concerning the details of which a volume could be written; suffice it to say that in the French armies there are several systems in use, all of which will locate to within a few yards an enemy battery at ten or twenty kilometers, indicate the caliber of the guns, differentiate between the sounds of discharge, flight through the air and bursting, and record each and every separate shot; and the spot from which the shot was fired may, under certain conditions, be located before the shell bursts. There have been developed several ingenious listening devices built on entirely different acoustical principles for use in mine warfare, by means of which enemy mining operations may be exactly located. Again for the location of sounds in the air, especially useful, for example, in locating airplanes at night, several new types of sound apparatus of extreme sensitiveness are in use. For submarine detection, some of the most promising methods for further improvement are based on the use of still other sound detecting devices. Wonderfully powerful megaphones for use in battle have also been developed.

Acoustics as an active branch of physics has most decidedly come into its own.

What about optics? One would expect this branch to show perhaps the highest developments and most interesting applications. Relative to acoustics, however, optics takes second rank as to new developments, although there are to its credit many beautiful modifications and improvements and not a few entirely new instruments, and the output of optical instruments is enormous. Optical signalling or observation, however, is not depended upon alone in battle, although several types are in use.

In photography and the technique of photographic map making there have been great improvements, brought about directly by military necessity, especially in aerial photography, apparatus and interpretation. One of our most interesting visits at the front was to the photographic headquarters of a French army corps, where we listened to an admirably delivered, illustrated lecture on the taking and interpretation of aerial photographs. There are at the front schools for training balloon observers, who have to reconstruct maps from their perspective photographs; certain of the aviators are similarly trained, although the making of maps from the photos they take is mainly the work of a special branch of the service. The art of map making from photographs, as carried out at the front, is practically a new branch requiring great skill, and is evidently of the first importance, as oftentimes the success of an offensive is largely dependent upon the quality of this work. These special services for which there are schools, are recruited from the army by competitive examinations, thus automatically obtaining the personnel best adapted.

As would be expected there have been not a few advances made in applications of electricity, especially wireless apparatus and methods, signalling and listening devices. There may be, for example, during a battle more than 1,500 separate wireless stations sending messages simultaneously; provision is successfully made for preventing interference and sorting out this great mass of signals so as to avoid confusion. Portable wireless outfits are supplied by the tens of thousand—requiring for the construction of these instruments alone a veritable army of skilled mechanics.

The reading public is, perhaps, more familiar with some of the applications of chemistry to warfare, such as the asphyxiating, tear-producing and other noxious gases used in waves or clouds and lately more and more in shells; and the importance

of nitric acid, toluol and the like has been impressed on every one. The stupendous scale on which such substances must be produced to keep up with the demands of the armies is perhaps not sufficiently realized, nor is there any adequate appreciation of the amount of scientific investigation being carried out. In France I understand there are some twenty-five distinct laboratories engaged in nitrogen fixation research alone.

Turning now to meteorology, what has the weather man to do with war? He too plays a capital rôle. With his sounding balloons he keeps the troops informed as to when a gas attack may be expected and when it would be profitable to start one; the artillery depend on him for data to calculate important corrections, as for wind, humidity, pressure, and temperature and upper air conditions in sighting their guns; the aviators as to prevailing winds, especially high up, and for general weather conditions; the balloon men keep in close touch with him, and even the transport service depends upon him for advance information as to muddy roads; headquarters relies upon him for knowledge of impending fog or rain and other changes—the weather man has a very heavy responsibility in helping to decide the most propitious moment for an attack on a grand scale, and if his forecast is erroneous, disaster may result. There is a special meteorological service—in fact there are two in addition to the regular service of peace times—attached to the French armies and linked to the British. The personnel, as in all the French services, is of the highest order of ability, being recruited largely from the professions and trades which depend upon the weather.

One of the most impressive sights we were permitted to witness at the French front was the firing of a battery of 320 mm. (13 inch) cannon, mounted on railway trucks, at an invisible target 19.5 kilometers distant. It took four shots to accomplish the end sought, which was demolishing an enemy battery that had been located the day before by “sound ranging” and photography.

What does such an operation mean in preparation and execution, viewed as a scientific experiment?

In the first place it presupposes an exact knowledge of the region expressed in accurate maps, including of course territory in possession of the enemy—the preparation of these maps is one of the most elaborate of the technical geographic services of the army; this service is usually supplemented when possible by triangulation from fixed observatories, and photographic mapping from airplanes or balloons; it assumes, further, that

the cannon of the battery have, as we might say, been calibrated, that is the characteristics of their firing determined by shooting at a recognized and exactly located object of about the same range and making a known angle with the target; the relative positions of battery and target and their exact distance apart should also be known. A big gun is displaced somewhat with every shot fired and is brought back to position by reference to a fixed base by means of a series of optical measurements. Some of the allowances and corrections that have to be made in firing are: variations in weight of projectiles—showing the need of uniformity, homogeneity and geometrical exactness in their manufacture, not a simple matter; weight, quality, age and temperature of the firing charge—which gives but a hint as to a most elaborate series of researches in the physical chemistry of ballistics; the age, state of erosion and temperature of the gun—another series of unsolved problems; the numerous atmospheric corrections such as direction and force of the wind at the various levels of the trajectory, the temperature, pressure, and humidity of the air, all of which produce disturbances that vary with the distance of the target or what is the same, muzzle velocity of the shot as well as the shape of the shell.

There have been prepared elaborate tables containing these corrections and others which are constantly being improved by further research; the theory of probabilities is also made use of in an elaborate way for each caliber to control the inevitable dispersion of the shots after all known corrections are made. With all these data, how does the artillery officer know the accuracy of his fire at a target invisible to him and 20 kilometers away? If he has the local mastery of the air use is made of airplanes which signal the location of each shot, otherwise he must depend on stationary balloons, special observatories or even on his calculations alone if the weather be bad.

Finally, it is not necessary merely for the shot to strike the target, it must explode at the right instant and have a suitable "fragmentation"—here is opportunity for more research in mechanics, chemistry, and metallurgy. It may be stated in passing, the French were compelled to develop a modified cast-iron or semi-steel shell, as they could not obtain enough steel for shells the first year of the war. It is not necessary to state that they succeeded in this.

Such in brief is the mechanism of artillery fire, for the accomplishment of which many of the sciences collaborate, and for the rendering it more exact there is still room for considerable research in astronomy, geodesy, metallurgy, chemistry,

physics, and meteorology. The battery we visited demolished the 20-kilometer-distant target at the fourth round, as was shown from photographs taken before and after firing—nothing is left to chance.

Turning to aviation, we need not dwell upon the wonderful advances that have been made in design of planes and motors, all of which has been dependent largely upon scientific investigation of the highest order, and numerous and varied are the research establishments, both governmental and private, for their execution. Here again one is impressed by the magnitude and grandiose scale on which this highly intricate and beautiful branch of the service has been developed. The scientific instruments alone with which the avions are equipped, say five types to a machine on the average, meant the development of an important technical industry in the products of which improvements are made almost daily.

We have not touched upon the applications of science in the various branches of military engineering, some of which are new in this war, requiring the highest directing, technical talent and thousands of workmen; the advances in medicine, sanitation and surgery have not been treated, nor have we mentioned trench warfare with its manifold engines, appliances and materials, necessitating the creation of new industries accompanied in all cases by elaborate scientific research. Gas warfare alone is based on what is literally a stupendous industry requiring the employment of chemists and other scientifically trained men on a great scale. Again there are large and very active laboratories maintained for the examination of enemy munitions and appliances of all kinds, and for the development of new and improved types.

A matter of vital importance is maintaining the quality and standards of the munitions supply, and this is done only by constant vigilance of the inspection and designing forces among which are many specialists of the highest grade and the total number engaged in this work amounts to many thousands. There is nothing so disastrous to the morale of the troops in battle as premature shell explosions. The quality of the steel must be beyond reproach. Here, as elsewhere, the United States will do well to profit from the European experience. The methods of steel casting as ordinarily practised in America are not considered abroad as entirely satisfactory for the production of "sound steel" from which shells, and especially high explosive shells, should be made. I had opportunities to visit several British and French steel works and shell plants, and my

observations confirm this belief, namely, that speaking broadly, the European steel-ingot casting practise is superior to ours, and I may add they consider theirs none too good.

For utilizing to best advantage the many suggestions and inventions that are proposed, there have been established, in Great Britain and France, inventions bureaus, to which are attached men of eminence in science and engineering. The most promising ideas are tried out under competent direction, and in some cases the board itself initiates and executes investigations of great military interest. Applications for patents may be held in abeyance and kept secret on the advice of this board.

A word now as to the organization of the scientific and technical services. Both the British and French, early in the war, saw the advantages to be gained by separating the fighting from the supply departments, hence the creation in each country of a ministry of munitions. It might almost be said that the able-bodied inhabitants of France belong to either the war or munitions ministry; or in other words the population is organized for war. The fundamental principle involved in this organization is that each shall do that for which he is best fitted in the national work of destroying the enemy. This principle admitted, the solution for any particular individual is a relatively simple matter; it is necessary of course for the administrative heads and military chiefs to exercise good judgment in the balancing of the organism as between military and industrial service.

Men most competent to give advice, such as the members of the Academy of Sciences, are asked for advice and they sit, as individuals or as representing the Academy, in an advisory capacity on many important committees. Men who have an aptitude for research are put to work in one or another of almost innumerable laboratories on problems of military importance.

Examples enough have been given to impress upon the reader, I hope, the tremendous magnitude, enormous scope and far-reaching extent of the problem of modern warfare looked at from the point of view of the applications of science and the employment of scientific and technical men.

The wonderful French organization was not all built up in a day, neither were mistakes avoided nor could all the developments that have taken place been foreseen. In the early days of the war men were sent to the front whose brains to-day would be an invaluable asset; national laboratories were almost

depopulated; the military authorities were indifferent to advice from civilian specialists. To-day one would be embarrassed to decide whether an officer in one of the specialized services was an officer before the war or, let us say, a professor of chemistry. The national laboratories have been multiplied ten-fold; and such care is now taken to protect productive brains that it may happen that the inventor of a new device is not allowed to go to the front to try it out.

In conclusion, I am tempted to quote the scientific definition of this war as given by a distinguished Belgian officer in the French service. The early incursions of the Germans were for the visible supplies of potential energy above ground—the cereals; the present war is their attempt to gain control of the sources of invisible potential energy below ground—coal and iron; and the next may be caused by their thirst for the sources of kinetic energy—the waterfalls.

FOOD IN WAR TIME¹

By Professor GRAHAM LUSK

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HERE is no doubt that under the conditions existing before the war the American people lived in a higher degree of comfort than that enjoyed in Europe. Hard times in America have always been better times than the best times in Europe. As a student in Munich in 1890 I remember paying three dollars a month for my room, five cents daily for my breakfast consisting of coffee and a roll without butter, and thirty-five cents for a four-course dinner at a fashionable restaurant. This does not sound extravagant, but it represents luxury when compared with the diet of the poorest Italian peasants of southern Italy. Two Italian scientists describe how this class of people live mainly on cornmeal, olive oil and green stuffs and have done so for generations. There is no milk, cheese or eggs in their dietary. Meat in the form of fat pork is taken three or four times a year. Cornmeal is taken as "polenta," or is mixed with beans and oil, or is made into corn bread. Cabbage or the leaves of beets are boiled in water and then eaten with oil flavored with garlic or Spanish pepper. One of the families investigated consisted of eight individuals, of whom two were children. The annual income was 424 francs or \$84. Of this three cents per day per adult was spent for food and the remaining three fifths of a cent was spent for other purposes. Little wonder that such people have migrated to America, but it may strike some as astonishing that a race so nourished should have become the man power in the construction of our railways, our subways and our great buildings.

Dr. McCollum will tell you that the secret of it all lies in the green leaves. The quality of the protein in corn is poor but the protein in the leaves supplements that of corn so that a good result is obtained. Olive oil when taken alone is a poor fat in a nutritive sense, but when taken with green leaves these furnish that one of the peculiar accessory substances, commonly known as vitamins, which is present most abundantly in butter fat, and gives to butter fat and to the fat in whole milk its dominant nutritive value. The green leaves also fur-

¹ An address prepared at the request of the U. S. Food Administration.

nish another accessory substance which is soluble in water and which is necessary for normal life. Furthermore the green leaves contain mineral matter in considerable quantity and in about the same proportions as they exist in milk.

Here then is the message of economy in diet, corn the cheapest of all the cereals, a vegetable oil cheaper by far than animal fat, which two materials taken together would bring disaster upon the human race, but if taken with the addition of cabbage or beet tops they become capable of maintaining mankind from generation to generation. One can safely refer to such a diet as a balanced diet.

This preliminary sketch shows several important fundamentals of food and nutrition. If one gives an animal a mixture of purified food stuffs, pure protein, pure starch, purified fat, and a mixture of salts like the salts of milk, the animal will surely die. But if one substitutes butter fat for purified fat, and adds a water solution of the natural salts of milk, the animal lives and thrives.

Again the illustration shows how corn may be so supplemented with other food-stuffs as to become extremely valuable in nutrition. It is especially valuable at the present time because corn is comparatively cheap and plentiful. But one asks how about pellagra? It must be here definitely stated that the use of cornmeal is not the cause of pellagra provided the right kind of other foods be taken with it. Pellagra occurs in the "corn belt" of the United States, and especially among the poorer classes in the south. The disease has developed since the introduction in 1880 of highly perfected milling machinery which furnishes corn and wheat completely freed from their outer coverings. In Italy, where the milling of corn is still primitive, pellagra is not as severe as with us, because the corn offal is not completely removed and this contains the accessory food substances or vitamins which are essential to life. Pellagra is generally believed to be produced by a too exclusive use of highly milled corn and wheat flour in association with salt meats and canned goods, all of which are deficient in vitamins. The administration of fresh milk is naturally indicated. Goldberger states that after the addition of milk to the diet of a pellagrins, the typical clinical picture of pellagra no longer persists. The poor in the mill towns of the South lived too exclusively upon a corn diet without admixture of milk or fresh animal food or even of cabbage and pellagra has been the consequence.

The Food Administrator asks us to eat corn bread and save the wheat for export. It is a very small sacrifice to eat corn

bread at one meal or more a day. Indian corn saved our New England ancestors from starvation, and we can in part substitute it for our wheat and send the latter abroad to spare others from starvation. The simplest elements of patriotism demand that we do this. Therefore let us cry "Eat corn bread and save the wheat for France, the home of Lafayette!"

Another point in war economy is the use of whole milk in greater quantity, and the diminution of the use of butter and cream. Cream is bought only by the wealthy, but in sufficient volume to largely reduce the amount of whole milk available. In Germany before the war 15 per cent. of the milk supply of that country was used for the production of cream. Regarding the use of butter a Swiss professor, himself an expert in nutrition, complains that whereas in his youth children were never given butter on their bread for breakfast, not even when there was no jam in the house, yet to-day absence of butter from the table is held to be indicative of direst poverty.

If one takes a pint of whole milk daily, or even, as we have seen, cabbage or beet tops in its stead, one may take fat in the forms of oleomargarine, olive oil or cotton-seed oil without possible prejudice to health. The legal restrictions placed upon the sale of oleomargarine and the taxes enhancing its cost, now in operation in many of our states, are without warrant in morals or common sense and should be entirely abolished in times like these. A well-made brand of oleomargarine is much more palatable than butter of the second grade, and certainly for cooking purposes is just as valuable.

Whole milk contains everything necessary for growth and maintenance, protein, fat, milk-sugar, salts, water and the unknown but invaluable accessory substances. It is of such prime importance that each family should have this admirable food, that I have suggested that no family of five should ever buy meat until they have bought three quarts of milk. The insistence by scientific men upon the prime importance of milk has probably had something to do with its rapid enhancement in price. This latter factor is greatly to be regretted. I have often wondered why it was that a quart bottle of a fancy brand of milk in New York should cost about as much as a quart of *vin ordinaire* on the streets of Paris, and a quart bottle of cream as much as a quart of good champagne in Paris. Despite much denial it appears to me that milk is not sold as cheaply as it ought to be. Everything should be done to conserve our herds of cows for the increased supply of whole milk and incidentally for the manufacture of cheese and of milk powder or of condensed milk.

If one takes milk with other foods meat may be dispensed with. Thus Hindhede advocates as ideal a diet consisting of bread, potatoes, fruit and a pint of milk. Splendid health, both of body and mind, the peasants' comparative immunity to indigestion, kidney and liver disease, as well as an absolute immunity to gout, is the alluring prospect held out by the following dietary:

Graham bread	1 lb.
Potatoes	2 lbs.
Vegetable fat	$\frac{1}{2}$ lb.
Apples	1 $\frac{1}{2}$ lbs.
Milk	1 pint.

This bread-potato-fruit diet gives a very excellent basis of wholesome nutrition. The potatoes yield an alkaline ash which has a highly solvent power over uric acid, and therefore a good supply of these valuable tubers is needed by the nation.

To most Americans the dietary factors here described will appear to be merely attenuated hypotheses, fit only for philosophic contemplation. For, in real life, it is the roast beef of Old England, or some other famed equivalent, that makes its appeal. Far be it from me to disparage the feast following a hunt of the wild boar or other feasts famed in song and story, but that is not the question. The question is, is meat necessary? The description of the Italian dietary answers this in the negative.

But is meat desirable? The Italian experimenters believed that the addition of 4 or 8 ounces of meat to the dietaries of some of their subjects increased their physical and also their mental powers. The increase in mental power due to change in diet has always seemed to me to be a figment of the imagination and not susceptible of demonstration. Thomas lived for 24 days on a diet of starch and cream, during 4 days of which time the very small quantity of 3 ounces of meat was taken daily, and he found his mental and muscular power unchanged.

A remarkable experiment on the effect of a potato diet has been reported by Hindhede. An individual partook of a diet of between 4 $\frac{1}{2}$ and 9 lbs. of potatoes daily with some vegetable margarine during a period of nearly three hundred days. The rule was to eat only when hungry and then the potatoes could be taken at the rate of an ounce a minute. During the last three months (95 days) of the experiment severe mechanical work was performed and the total food intake for the latter period amounted to 770 lbs. of potatoes and 48 lbs. of margarine. What could be more simple than stocking the cellar with coal,

potatoes and a tub of margarine! Who then would worry about the complexities of modern life?

Of course vegetarianism is no new thing. Its principal exponent was Sylvester Graham. It so happens that he was the brother of my great grandmother, and of him my father wrote in 1861 "long lanky Sylvester Vegetable Graham, leanest of men." Graham in 1829 began the advocacy of moderation in the use of a diet consisting of vegetables, Graham bread, fruits, nuts, salts and pure water, and excluding meat, sauces, salads, tea, coffee, alcohol, pepper and mustard. The first effect of this diet, which largely eliminated the flavors, was to reduce the weight through lowering the intake of food, but the health of many followers of the diet appears to have been benefited. The "Graham System" of dieting suffered from withering criticism at the time. He published in 1837 a little book entitled: "Bread and Bread Making," bearing on its cover the scriptural quotation "Bread strengtheneth man's heart." He says in this volume:

But while the people of our country are entirely given up as they are at present, to gross and promiscuous feeding on the dead carcasses of animals and to the untiring pursuit of wealth, it is perhaps wholly vain for a single individual to raise his voice on a subject of this kind.

The well-known work of Chittenden has shown that when the protein intake is reduced by one half or less of that which the average American appetite suggests, professional men, soldiers and athletes may be maintained in the best physical condition. One of Yale's champion intercollegiate athletes won all the events of the year in which he was entered while living on a reduced protein or Chittenden diet. Upon such a diet, or less than that, the people of Germany are now living to-day. The principle involves eating meat very sparingly, taking half a piece where one would have formerly been taken, and using it only for its flavor. The wing of a chicken has little meat on it and yet if eaten together with vegetables it gives the meal a different quality than it would have had without it, and to this extent its use is warranted. The muscles are active when hard labor is done, but the muscles do not need meat for the performance of their work. A fasting man may have considerable power. The popular idea of the necessity of meat for a laboring man may be epitomized in the statement: a strong man can eat more meat than a weak one, hence meat makes a man strong. The proposition is evidently absurd.

Indulgence in meat is due to the desire for strong flavor.

With the increased distribution of wealth, the demand for meat grows. Its consumption by all classes had vastly increased in all prosperous countries prior to the war. It is well, however, to remember that its use has been excessive and unnecessary, and its price can be cut by wholesale voluntary abstinence. The British people have suffered no hardship in the recent reduction of their meat ration.

A British Commission has reported to Parliament that it takes three times as much fodder to produce beef as it does to produce milk or pork of the same food value. Since cows eat chiefly hay and grass and pigs eat grain the cost of the production of a unit value of milk is much less than the cost of the same value in the form of pork. It takes only fifty per cent. more fodder to produce veal than to produce pork. Milk, pork and veal have long been the established protein-containing foods of nations on the continent of Europe. According to these figures beef should cost in the market twice what veal costs, and yet the butcher charges nearly the same for the two. It would save food for milk production if steers were eaten as veal and not fed up into beef cattle. If all heifers were developed into milch cows and no cow capable of giving milk in quantity were slaughtered, the country would be placed on a much better basis than at present. It would make beef expensive, but there is every reason why it should be expensive. It would increase the dairy business, which is evidently a need of the times, something for the protection of the welfare of mankind. For it must be remembered that a well-nourished cow during a single year will give in the form of milk as much protein and two and a half times the number of calories as are contained in her own body.

This was written before the publication of the following words of Armsby, the foremost authority on animal nutrition:²

Roast pig, to those who like it, is not only a delicacy but a valuable article of diet, but nevertheless, it is possible to pay too high a price for it, and while a proposal to restrict rather than to promote meat production in the present crisis may appear both irrational and unpatriotic it may nevertheless be in the interest of true food economy. . . .

It may be roughly estimated that about 24 per cent. of the energy of grain is recovered for human consumption in pork, about 18 per cent. in milk and only about 3.5 per cent. in beef and mutton. In other words, the farmer who feeds bread grains to his stock is burning up 75 to 97 per cent. of them in order to produce for us a small residue of roast pig, and so is diminishing the total stock of human food. . . .

The task of the stock feeder must be to utilize through his skill and knowledge the inedible products of the farm and factory such as hay, corn

² "Roast Pig," *Science*, 1917, XLVI, 160.

stalks, straw, bran, brewers' and distillers' grains, gluten feed, and the like, and to make at least a fraction of them available for man's use. In so doing he will be really adding to the food supply and will be rendering a great public service. Rather than seek to stimulate live stock husbandry the ideal should be to adjust it to the limits set by the available supply of forage crops and by-product feeding stuffs while, on the other hand, utilizing these to the greatest practicable extent, because in this way we save some of what would otherwise be a total loss. . . .

The hog is the great competitor of man for the higher grades of food and in swine husbandry as ordinarily conducted we are in danger of paying too much for our roast pig. Cattle and sheep, on the other hand, although less efficient as converters, can utilize products which man can not use and save some of their potential value as human food. From this point of view, as well as on account of the importance of milk to infants and invalids, the high economy of food production by the dairy cow deserves careful consideration, although of course the large labor requirement is a counterbalancing factor.

At any rate, it is clear that at the present time enthusiastic but ill-considered "booming" of live stock production may do more harm than good. If it is desirable to restrict or prohibit the production of alcohol from grain or potatoes on the ground that it involves a waste of food value, the same reason calls for restriction of the burning-up of these materials to produce roast pig. This means, of course, a limited meat supply. To some of us this may seem a hardship. Meat, however, is by no means the essential that we have been wont to suppose and partial deprivation of it is not inconsistent with high bodily efficiency. Certainly no patriotic citizen would wish to insist on his customary allowance of roast pig at the cost of the food supply of his brothers in the trenches.

Heat from the sun enters into the composition of the food substances when they are being built up in the plants, and this energy, which is latent in the food, is set free in the animal body and is used as the source of power behind all the physical activities of the body. The energy can all be recovered as heat and measured in the form of calories. According to the principles of the law of the conservation of energy, heat is not destructible. The understanding of the value of a calorie is indispensable for the comprehension of nutrition. A calorie is the measure of a unit of heat, or the quantity of heat necessary to raise a liter of water from 0° to 1° Centigrade. Apparatus has been invented for measuring the heat production of a man, an apparatus which is called a calorimeter or a measurer of calories. If one puts a man weighing, say, 156 pounds in the box of such an apparatus, so that he lies comfortably on a bed in complete muscular relaxation, and before his breakfast, one finds that he produces 70 calories an hour. Only in certain types of disease is there any variation from this normal, though of course the weight of the man makes a difference in his requirement for energy. If, at the same time the subject is in

the box, the quantity of oxygen which he absorbs is measured and if certain other chemical analyses be carried out, one can calculate the exact amounts of protein, fat, and sugar which have been oxidized by this oxygen. Now if one calculates how much heat ought to have been set free from the oxidation of these quantities of protein fat and carbohydrate, it is discovered that the heat which ought to have been produced is exactly that quantity which was measured as having been produced by the man. This measurement represents the *basal metabolism* of a man at complete rest, when his oxidative activities are at their lowest ebb.

The basal metabolism as measured by 70 calories per hour in the case of this individual represents the sum of the fuel needed (1) to maintain the beating of the heart, which every minute of a man's life moves the blood or one twentieth part of the weight of the body, in a circle through the blood vessels; (2) to maintain the muscles of respiration that the blood may be purified in the lungs; (3) to maintain the body temperature at that constant level which is so characteristic that a slight variation signifies illness, and (4) to maintain in the living state the numerous tissues of the body. Any extraneous muscular movements are carried out in virtue of an increased oxidation of materials and the heat production rises above the level of the basal metabolism with increased muscular effort. For a long time the power for the maintenance of the human machine can be furnished by its own body fat, as is seen in cases of prolonged fasting, but usually the power is derived instead from the food-fuel which is taken. The great question in the world to-day is whether or not a sufficient quantity of food-fuel is available to support the human family. The question of calories is not an academic one, but an intensely practical one.

The following values may be cited from the literature on the subject, as showing the daily requirement of energy for working people when the work day is of eight hours. A seamstress sewing with a needle required 1,800 calories. Two seamstresses using a sewing machine required 1,900 and 2,100 calories. Two women book-binders required 1,900 and 2,100 calories. Two household servants employed in such occupations as cleaning windows and floors, scouring knives, forks and spoons, scouring copper and iron pots required 2,300 to 2,900 calories. Two washerwomen, the same servants as last named, required 2,600 to 3,400 calories in fulfilment of their daily work.

Concerning the fuel requirement for the occupations of men: Two tailors required 2,400 and 2,500 calories. A book-binder required 2,700 and a shoemaker 2,800. Two metal workers filing and hammering metals required 3,100 and 3,200 calories. Two painters occupied in painting furniture required 3,200 and 3,300 calories and two carpenters engaged in making tables required the same amount of energy. Farmers of all nationalities—United States, Mexico, Italy, Finland—required 3,500 calories. Two stonemasons chiseling a tombstone required 4,300 and 4,700. Two men sawing wood needed 5,000 and 5,400 calories.

Other studies upon the requirements of lumbermen engaged in chopping and yarding logs, bicycle riders in six-day bicycle races and men engaged in long mountaineering ascents show that the demand for food-fuel may reach 10,000 calories daily.

It is evident from this analysis that whenever there is physical labor to be accomplished the demand for food-fuel increases. The present world food situation depends not only on a short wheat crop, but also upon the fact of an increased demand for food-fuel on account of an increased speeding up of the human machines, which latter factor includes a largely increased amount of muscular work done by women.

A British scientific commission has reported to Parliament that if the workman be undernourished he may by grit and pluck continue his labor for a certain time, but in the end his work is sure to fail. It makes no difference what the nutritive condition of the person is, if a certain job involving muscular effort is to be done it always requires a definite amount of extra food-fuel to do it. Rubner, the greatest German authority on nutrition, excited grossly inappropriate hilarity in the comic press of his country, by showing that a poor woman who waited several hours in line in order to receive the dole of fat allowed her by the government, actually consumed more of her own body fat in the effort of standing during those hours than she obtained in the fat given her when her turn to receive it came at last.

A method by which food-fuel can readily be saved with benefit to the nation and to the individual is for the over-fat to reduce their weight. This has been done with drastic severity in Germany. I have heard from unquestioned sources how a man who had weighed 240 pounds lost 90 pounds since the war began; how a corpulent professor at Breslau lost greatly in weight, but during the second summer of the war regained

his former corpulence during a sojourn in the Bavarian Tyrol, a joy not now tolerated; and how an American woman lost 40 pounds in weight last winter in Dresden. There is every reason why a man who is over-weight at the age of fifty should reduce his weight until he reaches the weight he was when he was thirty-five. According to Dr. Fiske he is a better insurance risk if after thirty-five he is under the weight which is the average for those of his years. Reduction in weight reduces the basal requirement for food, and reduces the amount of fuel needed for moving the body in walking. The most extreme illustration of the effect of emaciation upon the food requirement is afforded by a woman who after losing nearly half of her body weight was found to need only 40 per cent. of the food-fuel formerly required. This represented a state not far from the border line of death from starvation, but it indicates how a community may long support itself on restricted rations. It must be strictly borne in mind however that if any external muscular work is to be accomplished it can only be effected at the expense of a given added quantity of food-fuel, whether the person be fat or thin.

It is not at all difficult to reduce the body weight. Suppose a clergyman or a physician requires 2,500 calories daily in the accomplishment of his work and takes 2,580 calories per day instead. The additional 80 calories is the equivalent of a butter ball weighing a third of an ounce, or an ounce of bread or half a glass of milk. It would seem to be the height of absurdity to object to such a trifle. But if this excess in food intake be continued for a year the person will gain nine pounds and at the end of ten years ninety pounds. Such a person would find that he required a constantly increasing amount of food in order to transport his constantly increasing weight. In instances of this sort a motto may be applied which I heard the last time I was in Washington: "Do not stuff your husband, husband your stuff."

Now it is evident that, if instead of taking more than the required amount of food a little less be taken than is needed the balance of food-fuel must be obtained from the reserves of the body's own supply of fat. By cutting down the quantity of fat taken, or by eliminating a glass of beer or a drink of whiskey, and not compensating for the loss of these by adding other food stuffs, the weight may be gradually reduced. The amusing little book entitled "Eat and Grow Thin" recommends a high protein and almost carbohydrate-free diet for the accomplishment of this purpose, but its advice has made so many of

my friends so utterly miserable that I am sure that in the end it will counteract its own message.

The work of the world is accomplished in largest part by the oxidation of carbohydrates, that is to say of sugars and starches. Bread, corn, rice, macaroni, cane-sugar, these are *par excellence* the food-fuels of the human machine. They are all convertible into glucose in the body, which glucose gives power to the human machine. Fat may be used for the same purpose, but unless carbohydrate is also present a person can not work up to his fullest capacity.

As all the world is seeking for food-fuel with which to do work, I want to place before you a plea that the public be informed as regards the energy value of its purchases. It is but repetition of an already published statement.³

A barrel of flour weighs 196 pounds. One pound of flour yields 1,650 calories. One barrel of flour, therefore, contains 1,650 times 196, or 323,400, calories. The farmer in 1916 received \$1.50 a bushel for his wheat, which would make the barrel of flour cost about \$7.50. In February, 1917, the cost was \$9 a barrel, whereas in May of the same year it sold at retail at \$17 and more a barrel and in August the price had fallen slightly. These costs may thus be reckoned:

	Price Per Barrel of 323,400 Calories	Price Per 1,000 Calories
Flour, based on 1916 price of wheat		
paid to farmer	\$7.50	\$0.023
Flour, February, 1917	9.00	0.028
Flour at retail in New York, May		
22, 1917	17.12	0.053
August 27, 1917	15.29	0.048

Since one third of the food-fuel of America, England, and France is derived from flour, it is evident that the extortionate price exacted for bread, which has been called the staff of life, puts a severe load upon the human family and has placed under fire the modern machinery of food speculation which has made such prices possible.

Passing now to a consideration of the foods sold in packages, I bought at a department store on May 22 the following foods, at the following cost per thousand calories:

PRICE PER 1,000 CALORIES	
Cornmeal	3½ cents
Karo Corn Syrup	5½ cents
Wheatena	8 cents
Grape-Nuts	8½ cents

³ *World's Work*, August, 1917.

Sunshine Cheese Wafers	15	cents
Quaker Oats	4 $\frac{1}{2}$	cents
Cream of Wheat	5 $\frac{3}{4}$	cents
Corn Flakes	8 $\frac{1}{2}$	cents
Animal Crackers	11 $\frac{1}{2}$	cents
Nabisco Wafers	32	cents
Imperial Cheese	41	cents

I firmly believe that a great advance would be scored if the value in calories were placed on every food package sold.

As to the use of alcoholic beverages the question resolves itself into several factors. Alcohol gives a sham sensation of added force and in reality decreases the ability to do work. Alcohol is the greatest cause of misery in the world and as Cushman has put it, if alcohol had been a new synthetic drug introduced from Germany, its importation would long since have been forbidden. On the other hand good beer makes poor food taste well. It also frequently leads to overeating. The cure for bad food is to have our daughters taught how to cook a decent meal. After that we can talk about prohibition.

The food situation is probably more serious than most of us realize. The country should be stirred to a keener sense of its responsibilities. In conclusion, let us agree if we can to the following propositions:

1. Eat corn bread and save the wheat for France, the home of Lafayette, and for our other allies.

2. Let no family (of five persons) buy meat until it has bought three quarts of milk.

3. Save the cream and butter and eat vegetable oils and oleo-margarine.

4. Eat meat sparingly, rich and poor, laborer and indolent alike.

5. If fat, grow thin.

6. Be a prohibitionist for the period of the war (if you have enough resolution).

7. Save everything that can be used for food, because food is precious.

8. Finally remember that all the world is seeking for food-fuel with which to do work and that, though our wheat crop is short, still we are the nation most richly endowed with food-fuel. It remains to be seen whether we have the intelligence to fitly utilize for the welfare of mankind the resources which God and nature have placed in our hands.

SPECIFIC PREVENTIVE AND CURATIVE THERAPY, WITH SPECIAL REFERENCE TO GASEOUS GANGRENE

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THERE are two kinds of immunity—natural and acquired. Natural immunity to certain diseases is sometimes the common property of a whole species of animal, as in the case of the immunity of fowls to tetanus infection. Immunity may be acquired either through an attack of the disease, in which it may persist for a lifetime, or through protective inoculation with the bacterial bodies or their products. In the case of vaccination with the killed or attenuated bacterial bodies an active immunity is set up in the person vaccinated, his own body cells reacting in such a way to the bacteria introduced that actively immune substances, antagonistic to the specific bacteria injected, are produced within his body and exist in considerable quantities in his blood stream. Such an immunity, while not nearly so enduring as that acquired from an attack of the disease, may last for several years, and such a person, although he has never had the disease in question, is said to be actively immune to it.

Immunity may also be conferred upon one individual by injecting into his blood stream large quantities of the serum of another individual actively immunized to the disease. Such an immunity is said to be passive, because the body cells of the person inoculated take no part in it, the degree of immunity depending wholly upon the concentration of immune substances, or “antibodies,” in the serum injected. Immunity of this sort is, of course, very fleeting in character. It can be maintained only by repeated injections of the immune serum and is applied as a precautionary measure where there is a possibility of infection, as in tetanus, or as a curative agent in an acute disease like diphtheria.

Immune sera for therapeutic use are usually produced in horses. Such sera may be of two kinds. They may be produced with the bacterial bodies themselves, in which case they are called antibacterial sera; or they may be produced with

sterile filtrates containing the soluble toxic products of the bacteria, when they are known as antitoxic sera, or antitoxins. An antibacterial serum acts directly upon the specific invading microorganism and prepares it for destruction by the body cells, while an antitoxic serum, by neutralizing the toxin produced by the bacteria during growth, inhibits that growth and prevents its spread, thus giving the body a chance to destroy the bacteria. An example of an effective antibacterial serum is that used in the treatment of cerebrospinal meningitis. The meningococcus, which is the specific organism against which this serum is prepared, does not secrete in cultures a true bacterial toxin, but there can be prepared in horses, by the injection of the bacterial bodies, a potent serum which has proved extremely valuable in the treatment of this disease.

An example of an antitoxic serum is that prepared against diphtheria. Such a serum is produced in horses by the injection of the sterile filtrate from broth cultures of the diphtheria bacillus. This organism secretes, when grown in a suitable medium, a true soluble toxin which may be filtered through the finest filters and still prove fatal for guinea pigs in very small doses, after all the bacteria have been removed. It is only with a true secretory toxin like this that an antitoxic serum can be produced. The bacterial toxins so far shown to be of large practical importance are those of diphtheria and tetanus, and the sera prepared with these toxins are the only true antitoxins at present in general use. Certain antibacterial sera, notably that prepared with the Shiga dysentery bacillus, possess a degree of antitoxic power in addition to their antimicrobial properties, but it is insufficient to warrant their being classed with the true antitoxins.

The terms "vaccine" and "serum" are often confused, even used synonymously by laymen and physicians as well. They are very different in their biologic natures and fields of usefulness. It is considered expedient, therefore, to state here briefly the difference between a "vaccine" and a "serum." A vaccine, strictly speaking, is a suspension of the killed or attenuated bacterial bodies in some sterile fluid such as physiological salt solution. In the case of a disease like smallpox, where no visible bacterial agent can be demonstrated, the vaccine is made from the attenuated "virus," which is the living infectious agent. A serum, on the other hand, is the clear yellowish residual fluid remaining after blood has been allowed to clot and all the corpuscles and the fibrin have separated out. It contains none of the bacteria or toxin with which it may have

been rendered immune in the living animal body, but only those reaction products of the animal to the bacteria or toxin injected that make it a fit therapeutic agent for use against the organism that produced it. It differs from a vaccine in containing the reaction products of the animal to the bacteria or their toxins rather than the bacterial bodies themselves. The most widely and successfully employed vaccines are those prepared against smallpox, rabies, typhoid and paratyphoid fever. Their injection incites a reaction on the part of the body cells of the inoculated person and thereby confers an active immunity which is capable of warding off infection for a period of two or more years. Immune sera, such as diphtheria and tetanus antitoxins, confer, on the other hand, a passive immunity which lasts only about two weeks. Vaccines find their greatest usefulness as preventive agents, while antitoxins are of great value as both curative and preventive agents. Tetanus antitoxin is very widely used to prevent lockjaw after certain predisposing injuries; it possesses healing power also. Diphtheria antitoxin may be used to ward off the disease after known exposure to infection, but it is especially efficacious as a curative agent.

The organism with which the present article¹ is mainly concerned is known as *Bacillus welchii*. It was first described in 1892 by Welch and Nuttall, who found it in a human case at autopsy and gave to it the name of *Bacillus aerogenes capsulatus*—the “gas-forming capsulated bacillus.” Since then the organism has been described in human infections by men of various nationalities and has been given a different name by almost every investigator. In the United States it is known as *Bacillus welchii*; in France as *Bacillus perfringens*; in Germany as *Bacillus phlegmonis emphysematosae*, and an English investigator named it *Bacillus enteritidis sporogenes*. These are only a few of the names that have been given this same organism by the different men who have worked with it. The confusion arising from these variations is obvious.

Morphologically *Bacillus welchii* is a large, plump rod, with the ends very slightly rounded. It occurs singly or in pairs, and in infected tissues is often found in long chains or filaments. Both in artificial cultures and in infected tissue it forms large amounts of gas and acids. The gas is chiefly hydrogen and carbon dioxide. The acids are a mixture of organic acids, chiefly butyric. Both acids and gas are formed very readily in

¹ A fuller and more technical treatment is given in the paper by Bull, C. G., and Pritchett, Ida W., entitled “Toxin and Antitoxin of and Protective Inoculation Against *Bacillus welchii*” and published in the *Journal of Experimental Medicine*, 1917, XXVI., 119.

beef infusion broth, to which glucose has been added, the acidity increasing with the amount of glucose. A 3 per cent. glucose broth culture sometimes becomes 7 per cent. acid in three or four days. Growth in milk, to which litmus has been added, presents a characteristic appearance. The blue litmus milk first becomes pink, due to the formation of acids. Then the curd forms and is bleached, and finally the gas given off blows the curd to pieces, and all the whey is expressed. In such a culture we have manifestations of two of the chief characteristics of *Bacillus welchii*, namely the formation of acid and of gas.

This organism does not develop unless the oxygen has been at least partly removed from the medium in which it is grown, either by boiling or by exhaustion in a vacuum jar. It is therefore classed among the bacteria known as anaerobic, although it is not as strictly anaerobic as the tetanus bacillus or the virus of poliomyelitis. It is very widespread in nature, existing normally in the intestinal tracts of man and animals, in most samples of market milk, in dust, in wool, on the skin—in fact, almost everywhere. It is able to maintain itself under unfavorable circumstances and to grow again when the proper conditions are provided through its ability to form spores. These spores are highly resistant to influences that are fatal to the ordinary growing or vegetative form of the organism. They can stand without serious injury a degree of heat that kills all the vegetative forms. They require no nourishment and may remain alive and virulent for a very long time. This ability to form spores is the common property of a great many bacteria, of which fortunately only a few—tetanus, anthrax, malignant edema, *Bacillus welchii*, and possibly others—are pathogenic for man.

With an organism as widely distributed as *Bacillus welchii*, infection may easily occur. It has been cited as the cause of pathological conditions as unrelated as diarrhoea and inflammation of joints, but it is primarily an invader of muscular tissue, rarely gaining access to the general circulation during life. Furthermore, the muscular tissue must be lacerated and the wound deep to provide the most ideal conditions for its growth. Healthy muscle is usually attacked only after the bacteria have invaded an adjacent crushed and torn area. When infection is once established in such a crushed muscle, it spreads very rapidly. Large amounts of gas are formed, distending the tissues and escaping in bubbles into the open wound. There is an escape of fluid from the vessels into the infected tissues, producing what is known as an edematous

condition. The tissues in and around the wound are so injured by the growth of the bacteria that they die and become gangrenous. If nothing is done to check its progress, the infection spreads rapidly, gas becomes evident in tissues far removed from the primary focus of infection, death of the muscles and gangrene progress rapidly, and collapse and death soon follow. This is the condition produced by *Bacillus welchii* in lacerated muscular tissue and, on account of the large amount of gas formed in the necrotic muscles, is known as gaseous gangrene.

The incidence of gaseous gangrene in civil life is not high. A certain number of cases is always to be found in city hospitals, due largely to industrial injuries and street accidents, but they form a very small percentage of the total yearly hospital records. Under war conditions, however, gaseous gangrene becomes a very different problem. A very large number of the wounds received on the battlefields of Europe are infected with the gas bacillus. The country through which the armies are fighting has been intensively cultivated for centuries, and the rich earth is necessarily heavily infected with all manner of intestinal bacteria, the spores of tetanus and gas bacillus among them. Under the conditions of trench life the soldiers' uniforms become caked with this infected earth, and when shell wounds occur, a bit of cloth is usually carried deep into the lacerated tissue, and ideal conditions are produced for the development of tetanus or of gaseous gangrene. The tetanus problem is well solved by the administration of a prophylactic dose of tetanus antitoxin to every wounded man at the first dressing station, to guard against a possible infection. By this means the incidence of tetanus, once so appalling, has been reduced to relatively few cases, but the tetanus antitoxin has no effect upon the development of gaseous gangrene, being specific for tetanus. The wounded must therefore take their chances of gas infection with all its awful consequences which the vastly improved methods of antiseptis and wound irrigation have not yet entirely abolished. There is every reason to believe, however, that the antitoxin whose discovery at the Rockefeller Institute was recently announced by Bull and Pritchett will be as effective in preventing gaseous gangrene as tetanus antitoxin is in preventing lockjaw, and also that it will exhibit curative properties.

The theories of the manner of the destructive action of *Bacillus welchii* in the infected animal body are almost as varied as its names. Some attribute its injurious effect to the absorption of toxic decomposition products from the infected

and disintegrating tissues. Others consider that the harmful effects are due to the large quantity of gas formed, which, being unable to escape, collects in the tissues, gradually cuts off the blood supply by the pressure it exerts and so causes death of the tissues; this dead tissue is then invaded by putrefactive bacteria which disorganize it, and so gaseous gangrene is established. Still others have maintained that the pathological condition is due to the irritating effect of the large amount of acids formed in the tissues and have claimed to be able to reproduce in animals identical lesions and death by injections of the pure organic acids. These are only a few of the theories that have been advanced to account for the pathology of gas infection. It remains to present the theory of the toxic action of the bacilli.

In undertaking a study of gaseous gangrene, one is struck by the fact that the infection, though essentially a local one, *i. e.*, confined to a more or less circumscribed area and rarely, if ever, gaining entrance to the blood stream, is yet capable of causing extreme prostration and death, sometimes within a very few hours after the appearance of the first symptoms. This leads one to compare it with other infections, such as tetanus and diphtheria, which are also purely local in character, and in each of which the active agent is known to be a very powerful toxin, secreted by the bacteria during the process of growth and disseminated through the body by means of the circulating blood. Although neither tetanus nor diphtheria presents the extensive destruction of tissues that we find in gas infection, the other points of similarity make it reasonable to suppose that like them *Bacillus welchii* might secrete a true soluble toxin which is its chief weapon of offense, and without which it would be powerless to cause the lesions typical of gaseous gangrene. This supposition led to an effort to reproduce in the test tube the ideal conditions for growth that we find in deep, lacerated wounds of the muscular tissues—namely, absence of oxygen and a supply of raw muscle.² To this end a 0.2 per cent. glucose beef infusion broth was made up, glucose being the chief muscle sugar and especially favorable for the growth of the gas bacillus. To tubes containing ten cubic centimeters of this sterile broth were added fragments of fresh sterile rabbit or pigeon muscle. These tubes are inoculated with a pure culture of *Bacillus welchii* and after being incubated over night at 37° Centigrade are filtered through sterile filters. The clear amber filtrate thus obtained contains the soluble toxic products of the gas bacillus. Such a filtrate is capable of causing, in very small doses, the

² Bull, C. G., and Pritchett, Ida W., *loc. cit.*

typical picture of gaseous gangrene—edema of the tissues, extensive necrosis of the muscles, and death. Its pathological effects can be differentiated from the infection itself only by the absence of bacteria and of gas. Like all true toxins, it does not immediately produce its effect, but requires a latent or an incubation period. Its toxic action is not affected by neutralization with sodium hydroxide, a fact which rules out the acid as the principal cause of the lesions. It conforms in every way to the requirements of a true secretory toxin similar to those of tetanus and diphtheria. Finally it has been possible to produce with it a potent antitoxic serum which will not only neutralize the toxin so that it produces no lesion, but will inhibit the growth of the bacteria in the body. It has been possible to treat successfully well established infections, so that the lesions healed completely. And most important of all, complete immunity of at least two weeks' duration against both the toxin and the live bacteria can be conferred upon guinea pigs and pigeons by injecting them subcutaneously with a small amount of antitoxin. The animals so treated are entirely refractory, during this period, to subsequent injections of toxin and of live culture that kill normal guinea pigs in a very short time. These facts point to the possibility of a serum prophylaxis for gas gangrene as effective as that already used in the prevention of tetanus.

Rabbits, goats, and horses have all been made to yield antitoxic sera by injecting them subcutaneously or intravenously with carefully graded doses of toxin. At present several horses and goats are in process of immunization. These animals are injected at regular intervals and are bled from time to time to test the amount of antitoxin present in their sera. These antitoxins are carefully standardized, the number of antitoxic units in a cubic centimeter of serum being determined for each bleeding. In this way a record is kept of the increase in antitoxic power of the serum of each animal.

It would appear, then, that there is every reason to look to the serum treatment for a profound decrease in the incidence of and fatalities from gaseous gangrene due to war wounds. The ideal condition would be to give a prophylactic or preventive dose of the antitoxin to all wounded men at the first dressing station as is now done with tetanus antitoxin. In this way it is fair to hope that the development of gaseous gangrene may be prevented in many or almost all cases, besides which the antitoxin appears to be of distinct value as a curative agent in cases of gaseous gangrene already developed.

IS AN INFORMAL PEACE CONFERENCE NOW POSSIBLE?

By CHARLES W. ELIOT

PRESIDENT EMERITUS OF HARVARD UNIVERSITY

THE urgent international problem to-day is how to bring about a frank and sincere conference of the belligerent nations without an armistice—since neither group would now take the obvious risks of an armistice—a conference consultative and not arbitral, and only preliminary to the official conference of governments which must devise and propose a real settlement. This problem is difficult, but not insoluble.

After three years of warfare, strenuous and continuous beyond all precedent, the military situation to-day is described fairly well by the word stalemate. For each party it is inconclusive; and there is no umpire. Either party can hold the other in trench warfare. The Entente Allies can drive the Germans back for short distances; but neither side has as yet won a decisive victory in trench warfare, or captured an army in open country. Because of the superiority of the Entente Allies and the United States in number of men, industrial productiveness and financial strength, Germany in all probability can be brought to a condition of exhaustion before the Allies will be; but this result can be brought about only by prolonged and desperate sacrifices of human life and of the savings of the nations, and at the cost of infinite human woe.

Although all the nations involved are longing for peace, their governments are in no condition to discuss terms of peace. The political and industrial changes brought about by the war are tremendous; but they are manifestly incomplete. Democracies have been obliged to change many of their habitual modes of action; autocracies are facing internal agitations; one autocracy has just disappeared, but no stable government has as yet taken its place; many industries have to be carried on under new conditions as regards both labor and capital; and war itself is conducted in new ways which disregard the ethics heretofore thought to be universally accepted. There is a general wondering as to what is going to happen next, which indisposes responsible persons to large committals, or decisions

which can not be recalled. The Entente Allies do not state clearly their minimum demands or lowest terms for peace, and the Central Monarchies state no terms at all.

Under such circumstances it is wholly natural for combative and indignant men and women to say, "What is the use of talking with the German rulers about terms of peace; they will not keep their word, if they can obtain any military advantage by breaking it? We must fight till we are plainly victorious." On the other hand, the various official and unofficial statements of the terms on which the Allies would be willing to make peace produce on the German mind, so far as their opponents can discover, only this effect—"We are fighting a war of defense against dismemberment or imprisonment; we must fight to the last gasp in the hope that some favoring chance or discord among our enemies may save us from the threatened destruction." This is indeed a horrible dilemma; and many righteous men say that there is no way to escape from it, except by the overpowering of one or other of the combatants. Before settling down, however, to this long struggle, is it not worth while to try a limited preliminary experiment on human capacity for good feeling and sound reasoning even under the most adverse circumstances?

Even under the actual very discouraging circumstances, he would be a bold man who should affirm that it is impossible to bring appointed conferees from all the belligerent nations into one room for the oral discussion of subjects previously agreed upon, the conferees being selected by the several governments, but receiving no instructions either before or during the conference from the appointing powers, and having no power or commission except to make a brief, public report of their conclusions. The function of the several governments would be limited to the appointment of the conferees and the granting of the necessary safe-conducts. In order to keep the size of the conference moderate, each small state might be restricted to two conferees, and each large state to four.

The two principal subjects of discussion ought to be:

I. The means of so organizing the civilized world that international war can be prevented—by force, when peaceable means have failed.

II. The removal or remedying in good measure of the public wrongs, injustices and distrusters which contributed to the outbreak of the present war, or have been created during its course—wrong-doings and passions which will cause future wars unless done away with.

There follows a list of the subjects which might well be discussed under each of these two principal heads, the conference itself making choice among them.

Under I:

(a) Will the nations concerned publicly recognize as a settled principle of international action, that no nation shall henceforth attempt to exercise rule or domination over any other nation, large or small, occidental or oriental?

(b) Can the boundaries of the European states be so readjusted that no European population shall be held by force to an unnatural allegiance contrary to their wishes?

(c) Shall the freedom of the seas and of the canals and channels connecting great seas be placed under international guarantees for peace times but not for war times?

(d) Will all the nations agree that enlargements of national territory, extensions of national trade, and concerted migrations shall hereafter be brought about only by the consent and with the good-will of all parties concerned, and shall be maintained only by the parties' sense of mutual service and advantage? For expansion of trade, the universal reliance shall hereafter be the policy of the "open door"; and for relief from congestion of population, the policy of "peaceful penetration." Enlargements of territory by purchase or other voluntary contract shall be subject to the approval of the International Council. (See below.)

(e) Will the present belligerents agree to form an offensive and defensive alliance for the purpose of instituting and maintaining an international council composed of one delegate from each nation, and an executive commission composed of one commissioner from each of either three or five great powers—such, for example, as Great Britain, France, Russia, Germany and the United States, or the United States, France and Germany, the chairman of the commission to be in either case an American—and an international army and international navy, the function of all these bodies combined to be to prevent international war, if need be by the use of force, and therefore to see that forces adequate to that end are maintained on call, these forces to be decidedly superior to the existing armies and navies of any two nations combined? Other nations might later be admitted to that alliance by the joint action of the international council and the international executive commission, provided that their forms of government might properly be called constitutional or free, and that they were prepared to make some

substantial contribution to the effective forces of the alliance; but no such addition to the first group of nations should be made until at least five years had elapsed from the conclusion of peace.

(f) Will the nations agree that as soon as the international army and navy have been put into working order a gradual systematic reduction of armaments shall be made under the direction of the international council and executive commission, so soon as experience has demonstrated the safe limits of reduction?

(g) Will all the existing governments agree, in the interest of permanent peace, that for the future the power to declare war and to maintain war by taxation and borrowings shall reside in an elective assembly under conditions which give to the mass of the people, or their elected representatives, control over all questions of war or peace?

(h) Will all the nations agree to the suppression of secret diplomacy except as preliminary or tentative inter-communication; so that no treaty, understanding or international arrangement should take any effect until publicly discussed and approved in representative assemblies of the nations concerned?

(i) Inasmuch as the present war and many previous wars have been promoted and prolonged because of the existence in most nations of a permanent military class having no other occupation than war and preparation for war, will the belligerent nations now agree to abolish within a reasonable time, each by appropriate legislative and executive action, its "regular" or professional military class, and to substitute for its present military establishment an unpaid democratic army, analogous to the Swiss, based on universal training and liability to service? The Swiss army is here taken as an example because the military constitution of Switzerland has produced an extraordinarily effective army without creating a military class or a militaristic spirit in the Swiss people. Those nations in the alliance which maintain a navy would be expected to cause the navy to be manned on the same principles of universal training and liability to service; but the proportion of officers permanently employed may be larger in a navy than in an army because a larger proportion of a navy than of an army will be constantly on active service.

(j) Will the belligerent nations now consent to attempt to secure for the world through the measures indicated above, complete freedom from military or naval aggression?

(*k*) Will the nations represented in the new alliance agree that the expenses of the international council and executive commission shall be borne by each of the allied nations in proportion to its population, and that each nation shall pay the expenses of its quota in the international army and international navy?

(*l*) Will the belligerent nations now agree that another conference at The Hague shall be called soon after the close of the war to consider and recommend for adoption by the several nations a new body of international agreements concerning the conduct of war, to include the new arrangements necessitated by the use, not yet fully developed, of the high explosives, the submarine, and the airplane, and to include also the establishment of an international court with a suitable code of procedure, and of an international council of inquiry and conciliation to take cognizance of incipient international contentions?

Under II:

(*a*) The partition of Poland.

(*b*) The cutting off of Alsace-Lorraine from France in 1870-71.

(*c*) The failure to give Italy in 1866 certain territories long subject to Austria, but unquestionably belonging to the Italian nationality.

(*d*) The discords and enmities introduced into the Near East, and particularly into the Balkan states by the unjust treaties of 1878 and 1913, made under the oversight of the principal European powers.

(*e*) The destruction wrought by the German and Austrian occupation of Belgium and northern France, Poland and Serbia, and the Russian invasion of East Prussia; and the various means of restoring those countries, such as indemnities, repayment of fines and requisitions, and loans from any nations that are able and willing to make them at no interest for a time and a slowly rising rate up to a maximum of five per cent.

(*f*) The oppression of several distinct nationalities which have long been miserable under the control of Turkey.

The status of the German colonies lost during the present war would be another appropriate subject for consideration by the conference. The conference might also consider whether permanent international peace and a just constitution of the international council could be promoted by the application of the principle of federation to some groups of nationalities to

which that principle is not now applied, as for instance to the Scandinavian kingdoms as one group and the Balkan states as another.

It would certainly facilitate the proceedings of an international conference in the interest of durable international peace if it could be understood beforehand that all the participating nations had come to the conclusion that war on the modern scale, and with the new implements of destruction, is not an available means, in the present state of the civilized world, of settling international disputes or of extending national influence and power.

What democracy by its elected executive, or what autocrat can set this experiment on foot? Switzerland would seem an appropriate state to start the experiment, and provide the meeting-room.

A BOTANICAL TRIP TO THE HAWAIIAN ISLANDS

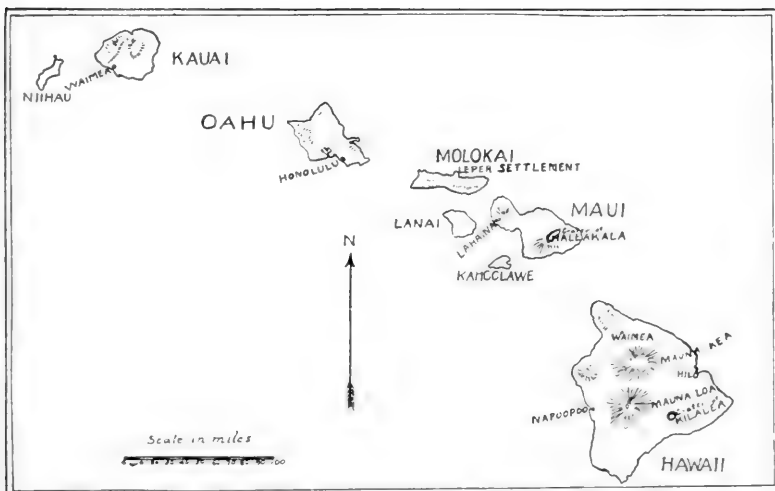
By Professor A. S. HITCHCOCK

U. S. DEPARTMENT OF AGRICULTURE, WASHINGTON, D. C.

DURING the past year I visited the Hawaiian Islands for the purpose of studying their flora, more especially the grasses. Accompanied by my son, Albert E. Hitchcock, as assistant, I spent about five months on the islands, leaving in November. I will give a short account of the country, emphasizing the features that I think will be of interest to botanists, my choice of these features being based upon my own impressions.

A brief account of the geography, topography and climate will not be out of place because, though these data may be obtained from the usual sources, they are unfamiliar to nearly all botanists who have not visited the islands.

The group consists of several large inhabited islands and many small uninhabited islands. The latter, mostly reefs and rocks, lie far to the northwestward of the main group. Among these are Bird Island and Midway Island. The main group consists of eight islands. These in the order of their size from the largest to the smallest are:



THE HAWAIIAN ISLANDS.



FIG. 1. A HAWAIIAN POUNDING THE TARO (*Calocasia esculenta*) TO MAKE POI, a starchy food much used by the natives.

Hawaii	4,015 square miles
Maui	728 square miles
Oahu	598 square miles
Kauai	547 square miles
Molokai	261 square miles
Lanai	97 square miles
Niihau	97 square miles
Kahoolawe	69 square miles

The islands are the most isolated on the globe. An idea of the vast expanse of surrounding ocean may be obtained from the table of distances from the nearest land in various directions.

To San Francisco	2,100 miles
To Tahiti	2,389 miles
To Samoa	2,263 miles
To Fiji	2,736 miles
To Yokohama	3,445 miles
To Sitka	2,395 miles
To Unalaska	2,016 miles

On account of this isolation the indigenous flora of the islands is comparatively meager, but contains a large proportion of

endemic genera and species. All the islands of the group were visited except the two smallest, Niihau and Kahoolawe. The latter is barren and windswept, and at present uninhabited.

The group lies just within the tropics in about the latitude of Cuba, but because of the vast expanse of water the climate, though technically tropical, does not have the high temperature generally associated in the layman's mind with the tropics. The daily maximum temperature in summer at Honolulu is about 85°, the minimum about 75°. The winter temperatures are a few degrees lower.

All the islands are of volcanic origin and are very mountainous. The mountains intercept the northeast trade wind with the result that the eastern sides of the islands have a heavy rainfall while the western sides are dry or even arid. The rainfall on the east or north slopes of the mountains may be from 100 to 300 inches, or on Waialeale (Kauai) as much as 600 inches per annum. On the other hand, the annual rainfall is below 15 inches on the southwestern sides of some of the islands.

The sugar industry is the most important and represents the investment of a large amount of capital. Sugar cane is grown on the four large islands on all the low lands where irrigation water is available. In spite of the heavy rainfall most of the plantations supplement this by irrigation, bringing the water from the mountains by means of ditches or aqueducts.



FIG. 2. AN OUTRIGGER CANOE AT WAIKIKI BEACH. The common form of native canoe.

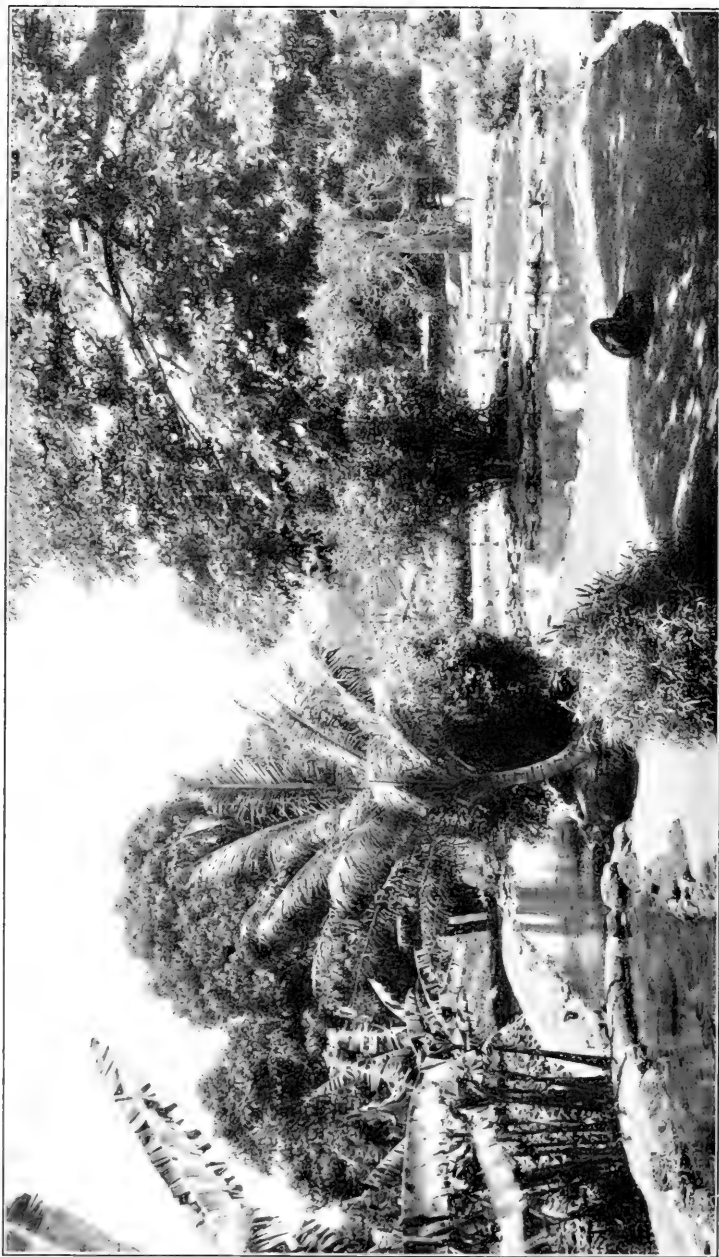


FIG. 3. VIEW IN MOANALUA PARK, HONOLULU.

Most of the sugar mills produce raw sugar, only one producing refined sugar.

The second important industry is stock raising. There are many large ranches devoted to the raising of cattle and sheep. The ranches occupy the land which is too dry for the successful growth of sugar cane. The island of Lanai is practically all one large ranch. The Parker Ranch upon Hawaii is said to embrace over 700,000 acres.



FIG. 4. THE MUNICIPAL BUILDING, HONOLULU, showing the gilded statue of Kamehameha in front. The tall palms are royal palms. At the left is an Araucaria.

The third industry is the growing of pineapples. In comparison with these three, the other agricultural industries are scarcely worth considering. Considerable rice is raised, mostly for local consumption, and there are a few coffee plantations in western Hawaii.

The native inhabitants of the islands, the original Hawaiian race, are fast disappearing, although there are a fairly large number of part-Hawaiians. The present population consists of Americans, Japanese, Chinese, Portuguese, Hindus, Koreans, Filipinos, negroes, and a scattering of other races or nationalities. At present the Japanese predominate. The staple vegetable food of the natives is poi, a product of the root of the taro plant (*Calocasia esculenta*). The starchy root is cooked and then pounded into a pasty mass (Fig. 1). The grass huts of the natives, now to be seen only in less frequented parts of the islands, consist of a framework of wood to which is attached



FIG. 5. A RESIDENCE IN HONOLULU WITH AN AVENUE OF ROYAL PALMS.

layers of pili grass (*Heteropogon contortus*), a common native grass on dry or rocky ground.

There are good roads on all the larger islands and travel in the inhabited portions is easy. The higher mountains are reached only by trails and are not easily accessible. Inter-island steamers facilitate travel from one island to another. One line leaves Honolulu in the forenoon and arrives at Hilo on Hawaii the next morning, stopping at Lahaina, island of Maui, on the way. Another line leaves Honolulu in the afternoon and arrives at Waimea, island of Kauai, the next morning. At



FIG. 6. MONKEY-POD (*Samanea Saman*), MOANALUA PARK. A beautiful round-topped tree frequently grown in parks. The grass in the foreground is Bermuda or manienie.

Lahaina one connects with steamers for Molokai and Lanai. There are other steamers that visit outlying points at varying intervals.

As the present article is not intended to be statistical, but



FIG. 7. A BANYAN TREE. The air roots around the trunk have become much condensed by trimming.

rather to give a record of personal impressions, the islands will be discussed in the order in which they were visited.

OAHU

Honolulu is the capital of the territory and is the only large city upon the islands. This is situated on the southwestern side of the island of Oahu, the locality being determined by the presence of a good harbor. The transpacific steamers drop

their passengers here, hence Oahu is the first island of the group to receive the attention of the traveler. Honolulu itself is a handsome city and altogether is the most delightful place it has been the writer's privilege to visit. Back of the city is

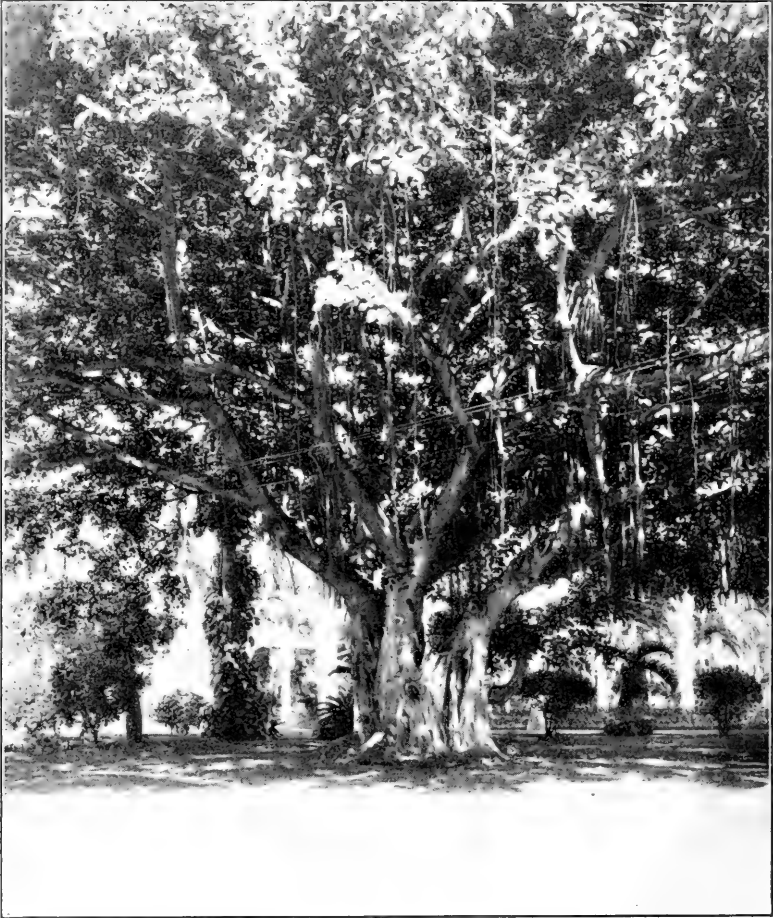


FIG. 8. A BANYAN TREE, showing numerous air roots hanging from the branches.

the Koolau range of mountains with many beautiful valleys lying between the steep ridges that reach down toward the shore at right angles to the main ridge. Honolulu occupies the plain along the coast and extends up into these valleys. A short distance beyond the limits of the city to the south is Diamond Head, a conspicuous promontory that dominates the landscape as one approaches by steamer. It is an old crater now occupied by fortifications. Between here and the city is the famous Waikiki Beach where the bathers throng and where one may see the celebrated surf riders and the outrigger canoes



FIG. 9. A FAMOUS HEDGE OF NIGHT-BLOOMING CEREUS AT PUNAHOU COLLEGE.

(Fig. 2). Another crater known as Punchbowl lies just back of the center of the city.

The visiting botanist is greatly impressed with the beautiful exotic plants in the gardens and parks and along the streets (Figs. 3, 4). The palms are conspicuous, among them being the royal (Fig. 5), the coconut and the date. Two common street



FIG. 10. NIGHT-BLOOMING CEREUS, a few flowers.

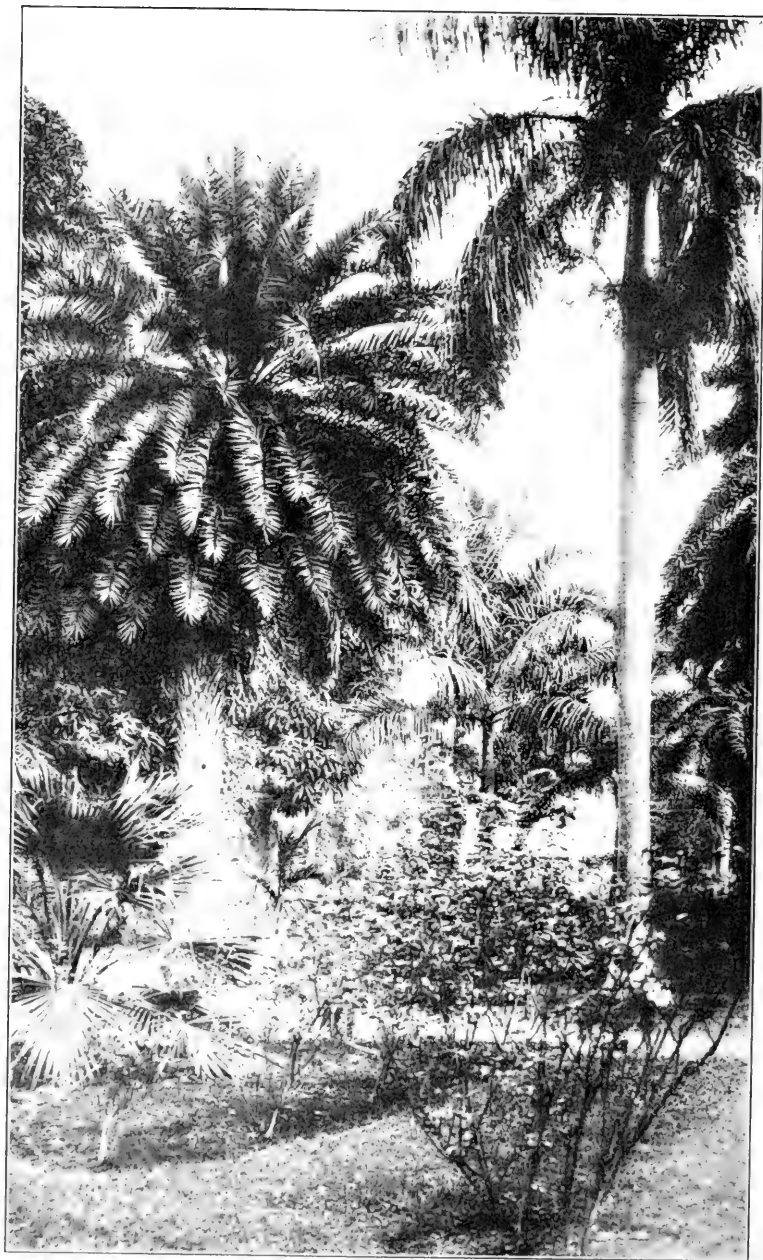


FIG. 11. VIEW IN THE HILLEBRAND GARDEN. This garden was formerly owned by Dr. Hillebrand, the author of the "Flora of the Hawaiian Island." It contains a great variety of exotic plants.

trees with strikingly beautiful flowers are the pink shower (*Cassia nodosa*) and golden shower (*Cassia fistula*). The latter has long, cylindrical, woody pods that look like a musician's baton. The hibiscus is much used as a hedge plant, there being scores of varieties, involving several species. The saman tree (*Samanea Saman*; *Pithecolobium Saman*) is a beautiful, symmetrical, roundtopped tree much grown in parks (Fig. 6).



FIG. 12. ALGAROBA TREE (*Prosopis juliflora*) near the College of Hawaii. This tree is well naturalized on the drier sides of all the islands, usually forming a belt near the coast. It is also used as a street tree. The pods are greedily eaten by stock and furnish a considerable portion of the forage in the dry season. The flowers furnish honey, which is an important product on many of the ranches. - The native name is klawe.

This is also called monkey-pod and rain-tree. The flame tree or royal poinciana (*Delonix regia*), familiar to the tourist in South Florida, is a deciduous tree, with very showy scarlet flowers that appear before the leaves. The banyan tree (Figs. 7, 8), with its numerous air roots hanging from the branches, is frequent in parks and lawns. The pepper tree, commonly cultivated in California, is planted along streets and drives. Clambering over a stone wall around Punahou College is a remarkably fine growth of night-blooming cereus (Figs. 9, 10). This cactus blooms en masse only at intervals of several weeks or months, though occasional flowers appear at irregular intervals. When in full bloom the effect is very striking. The large white funnel-shaped flowers, a foot long and several inches in diameter, open after sunset and close the following morning.



FIG. 13. KOA TREE ON NORTH SLOPE OF MAUNA KEA. An isolated specimen.

The accompanying photographs were taken between the break in day and sunrise, and the flowers had partially closed.

One of the favorite drives from the city leads over a pass in the Koolau Mountains. This pass, called the Pali or Nuuanu Pali, is about 1,200 feet altitude. The view from here is unusually fine. The trade wind blows through here with great force, at times so strong that the passage of vehicles is difficult, and pedestrians must make their way by aid of a wire cable stretched along the cliff. A remarkable effect of the strong wind is seen on a waterfall over a cliff to the west of the Pali. The water falls up instead of down. As it goes over the edge of the cliff it is caught by the wind and shoots straight up in the air.

There are two institutions in Honolulu of special interest to the taxonomic botanist. At the College of Hawaii, there is a large herbarium of Hawaiian plants in charge of Professor J. F. Rock, who has studied the flora intensively and has published several memoirs upon Hawaiian plants. Of special interest to visiting botanists are his two books, "The Ornamental

Trees of Hawaii" and "The Indigenous Trees of the Hawaiian Islands," both profusely illustrated from photographs.

The Bishop Museum possesses a large and important collection of ethnologic and natural history objects relating to the Hawaiian Islands and to Polynesia. There is a large herbarium of Hawaiian plants in charge of Mr. C. N. Forbes, who has traveled extensively over the islands and who has published several articles upon their flora.

Professor W. A. Bryan, professor of zoology and geology in the College of Hawaii, has published a book upon the "Natural History of Hawaii" which should be consulted by all botanical travelers.

The U. S. Experiment Station is in charge of Mr. J. M.



FIG. 14. KOA FOREST ON NORTH SLOPE OF MAUNA KEA. The trees as they look when crowded.



FIG. 15. SCHOFIELD BARRACKS. The western range of mountains is in the background, Mt. Kaala, the highest point in Oahu, being at the right. The grass in the foreground is mostly pilipiliula (*Chrysopogon aciculatus*). This is troublesome because the mature spikelets, with their sharp points, penetrate the clothing.

Westgate, formerly of the Bureau of Plant Industry, to whom the writer is indebted for many courtesies.

A fine collection of exotic trees and shrubs is to be found in the Hillebrand Garden (Fig. 11), now owned by Mrs. Mary E. Foster. This was once the home of Dr. W. Hillebrand, the author of the well-known "Flora of the Hawaiian Islands." Another fine collection of trees is in the grounds of the Board of Agriculture and Forestry, on King Street.

The flora in the immediate vicinity of Honolulu is disappointing. Scarcely a native plant is to be seen for several miles around, if one disregards plants of the beach and of the shore marshes. The moist open slopes are taken with Hilo grass (*Paspalum conjugatum*) and vast areas are overrun with guava and lantana (*L. Camera*). I saw enough fine yellow guavas going to waste to make guava jelly for an army. Of 60 species of grasses found around Honolulu, 50 species were introduced. An exotic tree, the kukui (*Aleurites moluccana*) has virtually become a weed, so widely is it introduced. The light green foliage is a striking feature of the landscape (Fig. 39).

An introduced tree of great economic importance is the algaroba (*Prosopis juliflora*), a relative of the mimosas (Fig. 12). This tree occupies great areas or belts in the low land near the coasts of all the islands, especially on the lee side. The flowers

furnish nectar from which an excellent quality of honey is produced—the annual output of the Molokai Ranch being in excess of 100 tons. The pods are eagerly eaten by all kinds of animals and furnish an important source of feed.

Probably the commonest tree in the islands is the ohia (*Metrosideros polymorpha*), a variable species found from sea level to 9,000 feet altitude. The bark resembles that of our white oak, but the flowers, myrtaceous in structure, with numerous protruding stamens, are bright scarlet, or sometimes yellowish, and very showy. The most important forest tree is the koa (*Acacia Koa*) (Figs. 13, 14) and in abundance is probably second only to the ohia (o-heé-a). The wood of the koa is used for cabinet making and for construction. The ukulele, a mandolin-like musical instrument, is usually made of koa wood; and the ancient war canoes of the natives were hollowed out from the trunks of koa trees. The leaves of this tree, whose relatives are mostly Australian, are to us peculiar in that they consist of lanceolate flattened petioles (phyllodea), though the young trees, or young shoots on old trees, show twice pinnate leaves with flattened petioles.

The interior of Oahu is a plateau lying between the eastern and western chains of mountains. On this plateau is situated Schofield Barracks (Figs. 15, 16), where are quartered many of the troops. The open ground here is fine for parade purposes but is covered with a pestiferous little grass called pilipiliula (*Chrysopogon aciculatus*) whose mature florets end



FIG. 16. STRATIFIED LAVA ON THE ROAD TO SCHOFIELD BARRACKS.



FIG. 17. A FOREST OF SCREW-PINE (*Pandanus odoratissimus*) near Hilo.



FIG. 18. VIEW ON MAUNA KEA, AT ABOUT 10,000 FEET, looking south, a small crater in the foreground, Mauna Loa in the distance, a cloud bank between.

in a sharp barbed point by which they easily penetrate the clothing of those who walk over it.

A common grass in lawns, parks, and dry open ground generally, is Bermuda or, as it is called there, manienie (*Capriola Dactylon*). An equally common but worthless grass in the wet regions is Hilo grass (*Paspalum conjugatum*). Both species are introduced.



FIG. 19. VIEW OF MAUNA LOA FROM THE UPPER PART OF MAUNA KEA, a cloud bank between.

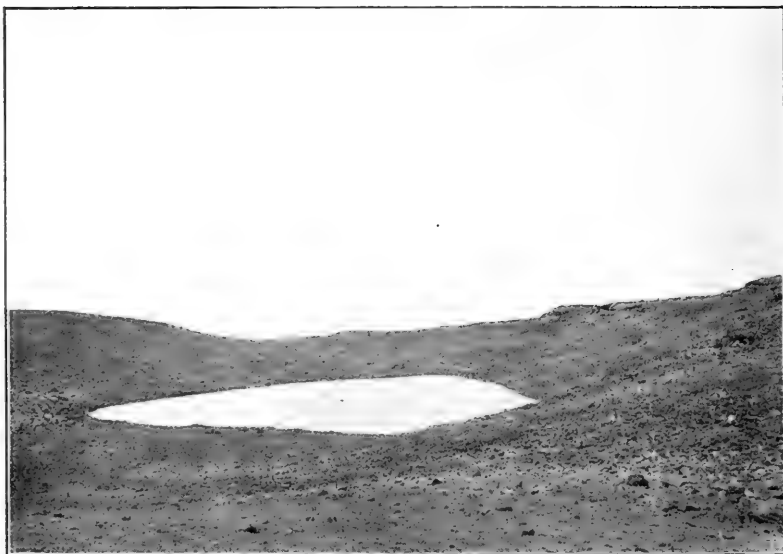


FIG. 20. SMALL LAKE NEAR SUMMIT OF MAUNA KEA. Altitude about 13,000 feet. Because of the porous lava soil lakes or ponds are rare.

HAWAII

The second island visited was Hawaii, the largest and southernmost of the group. This, the youngest geologically, presents greatly diversified examples of lava. We landed at Hilo, the largest town on Hawaii and the second in size in the islands. The rainfall here was excessive and the first thing done was to purchase a Chinese umbrella to protect ourselves against the frequent showers. In the low land along the coast in the vicinity of Hilo is a forest of puhala or screw-pine (*Pandanus odoratissimus*), a monocotyledonous tree with branched

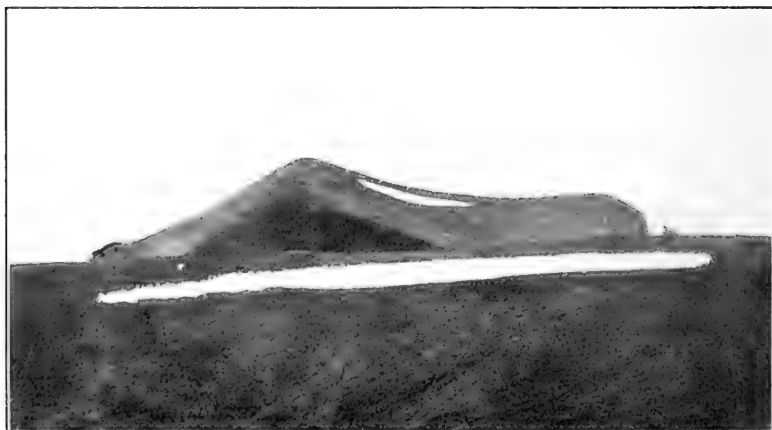


FIG. 21. SNOW BANKS NEAR THE SUMMIT OF MAUNA KEA.

stems, aerial roots, and great compound fruits like pineapples (Fig. 17).

We went by rail to Kukaiaiu where we were met by Mr. McAllister, manager of the Kukaiaiu Ranch, who took us to the ranch on the northern slope of the island. On account of the lack of running water rainwater is collected by means of large sheet-iron roofs supported on posts, and conducted into tanks or



FIG. 22. A SNOW BANK NEAR THE SUMMIT OF MAUNA KEA.

ponds. The ranch runs well up on the slopes of Mauna Kea. At the upper stretches, 4,000–8,000 feet, many of the common meadow and pasture grasses of the United States are thriving. Among these are blue-grass, orchard-grass, meadow fescue, meskit or velvet-grass, and Italian rye-grass. Natal-grass (*Tricholaena rosea*) was common at lower altitudes. *Paspalum dilatatum* is giving excellent results as a pasture grass.

The next stage of our journey was the Parker Ranch, the largest ranch in the island. Our headquarters were at the residence of the manager, Mr. Alfred W. Carter, near Waimea. The Kohala Mountains near by are very wet, but much of the land in the interior is dry. The great interior plain between Mauna Kea and Mauna Loa is covered with grasses, composed largely of species of *Eragrostis* (*E. atropioides*, *E. hawaiiensis*). Through the courtesy of Mr. Carter we were able to visit the summit of Mauna Kea. There are two high moun-

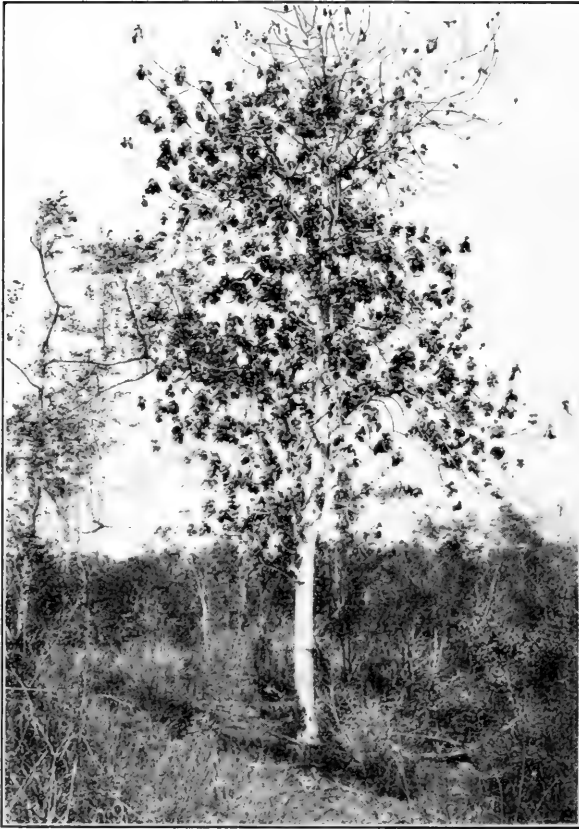


FIG. 23. A KOKIO TREE (*Kokia Rockii*) IN FOREST ON LAVA FLOW NEAR PUU WAAWAA. An ally of the cotton with large red flowers. Endemic in this region and consisting of rather few individuals.

tains on the island, Mauna Kea to the north, 13,825 feet altitude, and Mauna Loa to the south, 13,675 feet altitude. These mountains slope rather gradually from the sea to the summit. They form an immense cone rising from the floor of the ocean 18,000 feet below the surface, or about 32,000 feet altogether.

We were taken by automobile to the Humuula sheep-station on the south slope of the mountain at an altitude of about 6,700 feet. The following morning we ascended the peak on horseback. The upper stretches, consisting of cinder slopes, are tiresome to travel over, but not dangerous. At about 9,000 feet we rose above the clouds which now lay as a billowy white ocean between the two mountains (Figs. 18, 19). The upper forest consists largely of mamani (*Sophora chrysophylla*). At about 10,000 feet the trees disappear and the sparse vegetation consists of low shrubs and bunch grasses. The latter consist chiefly of three species, *Agrostis sandwichensis*, *Deschampsia australis*,



FIG. 24. HALAPEPE TREES (*Dracana aurea*) ON AA (ROUGH) LAVA, PUU WAAWAA.
The leaves are eaten by cattle.

and *Koeleria glomerata*. Not far from the top there is a small lake of clear palatable water, an unusual sight, as lakes are rare in the lava soil of the islands (Fig. 20). There are many banks of snow in protected places among the cones on the summit (Figs. 21, 22). There is considerable snowfall in the winter and many banks persist throughout the year.

Our next stop was at the Puu Waawaa Ranch in North Kona on the western side of the island near the Hualalai Mountains. This ranch is owned by Mr. Robert Hind, through whose courtesy we visited the top of the Hualalai Mountains, the highest peak of which is 8,269 feet. The ranch takes its name from an isolated hill or old volcanic cone fluted with deep gullies, the top covered with forest. All the water upon the ranch of over 150,000 acres is rainwater impounded in large tanks, several of which hold 100,000 gallons each. Mr. Hind has a fine meadow of Rhodes grass which yields crops of hay several



FIG. 25. COOK'S MONUMENT ACROSS THE BAY FROM NAPOOPOO. This marks the spot where Captain Cook was killed.

times a year. It is upon Mr. Hind's place that is found the tree cotton or kokio (*Kokia Rockii*), a peculiar plant allied to the cotton, with gorgeous crimson flowers about four inches long (Fig. 23). The trees are scattered in the scrubby timber on rough lava southwest of Mr. Hind's house, but are not known to grow elsewhere. There is also here a forest of halapepe (*Dracaena aurea*), a liliaceous tree resembling some of our western yuccas (Fig. 24). The leaves are fed to cattle when there is a shortage of forage.

The next stop was made near Honaunau in South Kona, at the place of Mr. Jared Smith, formerly director of the Hawaiian Experiment Station. Mr. Smith kindly placed his cottage at our disposal. Being directly west of Mauna Loa, we made a

trip up through the rain forest to an altitude of about 3,000 feet. Ferns were here the dominating feature—a bewildering variety. Near Honaunau is Napoopoo, across the bay from which is the monument (Fig. 25) erected to mark the spot where Captain Cook was killed by the natives in 1779. At Honaunau on the coast is the City of Refuge, an enclosure used by the early Hawaiians as a sanctuary to which those in peril might flee for protection. The walls are twelve feet high and fifteen feet thick (Fig. 26).

We were taken by automobile over an excellent road around the south side of the island to the Crater Hotel near the volcano of Kilauea. The crater is at an altitude of about 4,000 feet and measures about three miles from north to south and two miles from east to west, the floor being nearly 500 feet below the rim (Figs. 27, 28). Near the south end of the crater is the lava pit, called Halemaumau, in which the liquid lava is now in a state of activity, boiling and splashing, and throwing up great fountains of spray. It is one of the most marvelous natural phenomena it has been my good fortune to observe. The view at night is especially wonderful. The red-hot lava breaks on the shores of the lake with a sound like breakers on the sea-coast. Fortunately the lake can be viewed in safety from the rim, as the upheaval of the contents is not violent enough to endanger the onlookers.



FIG. 26. CITY OF REFUGE, HONAUNAU. "A stone wall twelve feet high and fifteen feet thick encloses seven acres of tabu ground; to such sanctuaries women and children, warriors worsted in battle, criminals and others in peril might flee for safety from their avengers." (Bryan, "Natural History of Hawaii.")

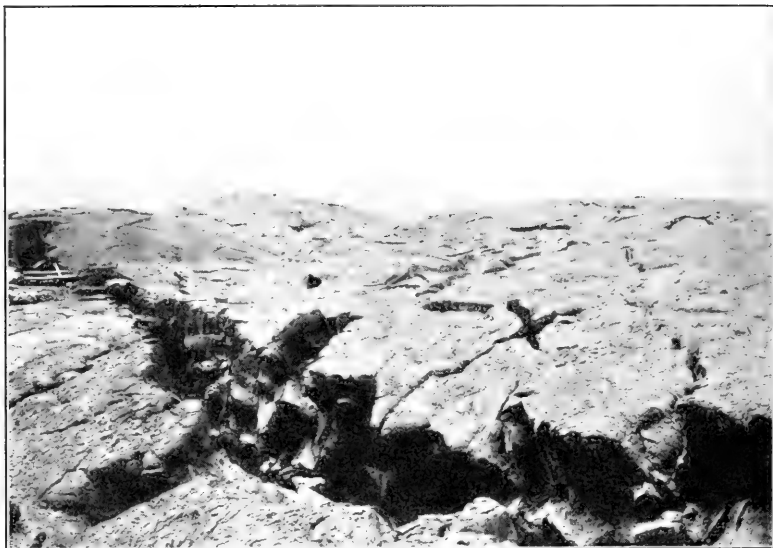


FIG. 27. A CRACK IN THE LAVA IN THE CRATER OF KILAUEA.

With the aid of Mr. Short, the kindly keeper of the Crater Hotel, we arranged for the ascent of Mauna Loa. Two saddle horses and a pack horse were obtained at the Dent Ranch near the volcano. We went without a guide, taking bedding and enough food for three days. We reached a resthouse on the east flank of the mountain at an altitude of about 10,000 feet, where we remained for the two nights. The resthouse contains



FIG. 28. EDGE OF A LAVA FLOW NEAR THE LAVA PIT.

cooking utensils, a few articles of furniture, and an oil stove with a supply of oil. Water is supplied from a rainwater tank.

We started on the ascent as soon as it was light the following morning, taking a canteen of water, a light lunch, the plant pick, and our large camera with its tripod. There is no definite trail, but the way is marked by monuments. For three or four miles these monuments are staffs with white metal disks, but beyond this there are piles of stones with a white rag fastened around the uppermost stone. The lava is very rough and is very wearing upon the shoes. There seems almost an infinite variety of lava (Fig. 29) and there are many caves, craters and chasms that attract one for further exploration. Bubbly lava, covering large areas, is tiresome or even dangerous to traverse. What appears to be a hard surface proves to be a thin coating



FIG. 29. LAVA FORMATION ON MAUNA LOA (pahoe-hoe or smooth lava).

over air spaces varying in depth, but usually not over fifteen or twenty inches. The sudden fall through the crust produces a very disconcerting sensation. Dangerous chasms and caves abound, but may be avoided in the day time by using normal caution. The crater at the summit, a distance of about ten miles from the resthouse, was reached about 2:30 P.M. Time did not permit a descent into the crater, but photographs were taken giving a general view with snowbanks in the distance. About half an hour was spent here. One of my shoes had been dangerously worn on the sole, though thickly hob-nailed. It



FIG. 30. ROAD FROM GLENWOOD TO VOLCANO HOUSE. Ferns very abundant. *Frey-cinctia Arnottii* climbing an Ohia Tree (*Metrosideros polymorpha*).

became necessary to do something to the shoe to protect the sole. Fortunately I had found a discarded fruit can which we were able to utilize for the purpose, otherwise I should have been in a dangerous condition, miles from the resthouse, on rough lava, with my foot unprotected. We commenced the return at 3:00 P.M., but were able to traverse only about half the distance before being overtaken by darkness. Little progress could now be made until the nearly full moon rose about 7:00 P.M. As

soon as the light was sufficient we were able to go faster, but the monuments could be located only with difficulty. I remained with one monument until Albert had located the next. In order to avoid the dangerous places the trail takes unexpected turns, thus increasing the difficulty in finding the successive monuments. After about a mile or less of this we lost the trail and determined to make for a hill a mile distant which we thought we had passed on the outward trip. This we did and picked up the trail again. However, in a short time we were again lost. After searching through an entire circle for the next monument we decided again to go eastward toward a distant hill from the top of which we might determine our position. These trips across the lava were exceedingly tiresome and were accompanied by no little danger. We got into bubbly lava from which there seemed no exit and in which we were threatened with engulfment at every step. Chasms and pits were avoided by a hair's breadth. The slanting moonlight made everything shiny bright on one side and black as night on the other. Frost was settling on the rocks, adding to the confusing reflections. At sundown we were so tired we could hardly put one foot before the other. But the dangers of the night travel banished our fatigue for the time being. We finally reached the hill for which we were making, ascended it only to find ourselves looking down into a crater and with no view to the east. We were lost, cold, hungry, thirsty, and ready to drop from exhaustion. To remain inactive till morning invited death from the cold. As it was necessary to keep moving, we decided to proceed eastward in the direction we thought the resthouse to be. After descending the cone Albert thought he saw a staff in the distance to the north. Examination proved the correctness of his surmise. The trail was recovered! We were able to follow the monuments, but it took us two hours more to reach the resthouse. The piece of tin on my shoe had worn through and the leather of the sole was at its last point of resistance.

We returned to the Crater Hotel the following day none the worse for our adventure.

A short time was spent at Glenwood with Mr. Thompson the superintendent of the station located here, a branch of the U. S. Experiment Station at Honolulu. We are here in a very wet region. Visitors to the volcano usually come by rail from Hilo to Glenwood, the terminus, and continue by automobile bus over a beautiful fern-lined road to the hotels (Fig. 30), a distance of 8 miles. Or one may go the entire distance from Hilo by auto, about 35 miles.

(To be continued)

THE TRACK OF EVOLUTION

By Professor S. N. PATTEN

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IN a recent talk with a friend about the lack of sympathy between the workers in physical and social science he asked, "What contribution since that of Malthus has been worthy of consideration?" Malthus, he admitted, helped to arouse the leaders of biologic thought, but who, he asked, had given a definite contribution since that time? The question demands an answer, or at least some discussion of the points involved. It must be admitted that the economists are defective both in their reasoning and in their psychology, but it should also be recognized that there were obstacles to the use of objective measurements in social science which were hard to surmount. Until the pathway is cleared objective measurements, while seeming to add to the clearness of thought, have in reality added to its confusion and furnished more meager results than did a legitimate use of older methods. There have been endeavors to use the method of physical science, but real students have found that beneath the formula taken from mathematics or physics lay hazy ideas and a species of dogmatism that prevented an open-minded consideration of the facts. Every crank, and his name is legion, poses as a scientist and has his formulæ modeled after the latest statement of scientific truth, but this pretense has only been a cloak for ignorance and dogma. If the scientist suspects the economist, the economist in turn suspects the new-comer who trades in the symbols of physical science. Some progress has thus been made even if the results are not so definite as those of physical science.

The defects in the social sciences are due to the imperfections in the physical sciences on which they are based. The economist must follow, not precede, the physical scientist? If the economist fails the original fault is not with him, but in the partial development of the sciences on which he depends. Subjective standards have been adhered to because of the lack of objective data. In many fields one has to choose between making physical science and falling back on the loose basis of thought on which the older economic science rested. It is no wonder that under these conditions economics has failed in its

main mission and its workers are compelled to endure the sneers of those in more fortunate fields of work.

Were I thinking only of making this complaint I would have remained silent. There seems of late some alterations in related sciences raising the hope that a new epoch has come in which the social and physical sciences may cooperate for a common advance. The route to this understanding I shall point out both as to where agreement has been reached and where a gulf still remains. Economic change must be one of a group of changes each of which is an essential step in progressive evolution in order that its conclusions may be put on a par with other contributions. I found that a start could be made in this direction, but no full solution was possible while certain views of physical science persisted. The law of diminishing returns assumes that men have a few stable wants, in the satisfaction of which a keen and destructive struggle arises. The increasing demand for any commodity causes an extension of its production to a point when diminishing returns begin. Men, however, gain relief by changing their wants and thus bringing into use new natural forces. An evolution is thus forced from old objects of consumption to the new, and from objects of which nature is less productive to those of which the yield is more generous. Potatoes and sugar may displace meat and wheat bread. I had little difficulty in proving this point, but the next step was blocked by a supposed physiological principle. It was contended that the cheap food made a low type of man. The rare foods like meat and bread stimulated a higher sort of energy and gave to those who use them a physical and mental superiority that was decisive in every world contest. The Irish potato-eater was doomed to a subordinate position in comparison to the English, who used a more costly food. Economic progress and physical progress were thus put in opposition.

This obstacle no longer exists, or at least is in a fair way to be removed. The cheaper foods have of late proved their worth. The vigor coming from the use of meat is in no way superior to that of bread, potatoes, or rice. If but one article or some few articles were used, wheat bread and meat might prove their superiority to the potato or rice; but as the variety of food increases the deficiencies of each sort of cheap food are made up by the excellence of some other food. The cheaper diet as a whole proves its superiority over the old meat and bread diet.

The prevailing theory of the past also assumed that to be well-nourished and prosperous led to indulgence, dissipation, and degeneration. The strong, vigorous person was assumed to

be he who was somewhat underfed, or at least so poor that over-indulgence was impossible. There is a measure of truth in this view, as also there is in the statement that the users of dear food, bread and meat, have been the superior races. By heredity our stomachs are used to coarse food. The primitive man could only occasionally secure the concentrated food the prosperous now use. He faced periods of actual starvation each year, and thus the indulgence of one season had its influence counteracted by the want of another. Our stomach troubles are due to a change to a concentrated diet, a change which was promoted by the belief that the dearer foods gave a superior energy to that derived from cheap foods. The measure of energy is not the quantity of food taken into the stomach, but the quantity of pure blood that results from the digestive process. There are also numerous glands the right action of which is an element in blood values. The best food when eaten too freely may be turned into toxins, and thus be harmful instead of beneficial. This is especially true of meat foods, which are so liable to be transformed into noxious compounds.

The word toxin describes the injurious contents of the blood, but we have no term that designates its beneficial contents. We talk in terms of fat, oxygen, protein and carbohydrates, but stop when the peculiar function of each has been described. To supply this gap and to enable me to state my theory in simple terms I shall call all the ingredients of the blood that promote activity "nutrins," and thus make a clear contrast between the nutrins that increase energy and the toxins that depress it. The man improves as the nutrins in the blood increase. High-priced food, indigestion, and toxins represent the elements adverse to the growth of energy, while cheap food, a varied diet, and more nutrins are its upbuilding forces. We can, if we will, study each of these elements by the method of physical science and remedy each defect. Much has been done in all these fields in recent years. The war has forced each nation to solve its food problem, and to make the people's consumption of food harmonize with known facts.

"Consciousness," says a recent writer, "is a response to environmental stimuli." The environment excites the nerves, and nerve evokes consciousness. This theory has come down to us from the time of Locke, and is the standard explanation of psychic phenomena. The mind is a blank except as it gets a content through nerve excitation. These nerves are a biological inheritance, a mechanism that has taken ages to develop. By them the external stimuli and the internal response are brought into harmony. Are they the source of this internal response,

or do they merely direct a pulse that has an independent origin? Is consciousness a chemical transformation or a biological mechanism? Are its antecedents in the blood or in nerve irritation? The best answer to these questions comes from watching the action of glands and in measuring their influence in creating states of consciousness. The glands accumulate their material and either overflow by the increasing pressure of their content or discharge as the result of nerve stimuli. If it is a self-discharge we dream; if the discharge results from nervous stimuli thought becomes logical and adjustive. The nerves are thus a mechanism not for creating consciousness, but for making thought currents run parallel to external events. They conserve life, but they are not its source.

If this explanation is correct the antecedent to consciousness is a gland discharge creating a pulse that becomes thought through the nerve mechanisms turning the pulse into motor power. The content of a gland is like the steam in a boiler, which by itself merely has explosive power, but which by the mechanisms of the engine is transformed into a steady working force. Nerve development, like improvements in the engine, increases adjustment as the engine creates force, but in neither case are they the seat of the ultimate power. No explanation of movement is possible in terms of engines or nerves. This is readily seen in the case of an engine. Is it not equally true of nerves?

Bear in mind that this is not an attempt to explain consciousness without nerves, but an endeavor to show that explanations of consciousness merely in terms of nerves is doomed to failure. Such explanations lack the true starting point and hence fail to connect consciousness with its chemical antecedents in the blood. From blood to gland, from gland to pulse, and from pulse to nerve reaction is the series through which our life processes go. The pulse in terms of consciousness is emotion; nerve excitation becomes ideas. When the two blend we have the higher life for which we yearn. Each pulse starts as emotion and is transformed into clear thought as the various nerve reactions determine the channel in which it moves. If this be true, dreams and wishes represent the early stages of thought movement when the emotional pulse is dominant. The clue to their origin lies in emotions that are non-adjustive, and not in the useful reactions which harmonize life with its environment. We must start with the glands and connect them with dreams and wishes.

If sex discharges result in sex dreams we have a ready

means of connecting gland activity with conscious emotion. Even if it be admitted that some dreams are not sex dreams they undoubtedly are the most elementary of our dreams. Here plainly a discharge antedates consciousness and colors its content. The philosopher Kant claimed that space and time were subjective forms, and thus the ultimates of thought. It would be nearer the truth to say that sex images are thought's ultimates. The pulse starts in a movement towards sex images, and would end there if our inherited nerve mechanisms did not censor the pulse and force it in other directions. Conscious thought has a foundation in sex but a superstructure of sense impressions. The external elements are magnified because of their usefulness, while the internal are distorted or suppressed.

It is worth asking how perfect these sex images would be if no sense impressions came from the outside to make them definite and clear. Our dreams are not purely subjective. Suppose a healthy child should grow up with no sensory nerves to bring in external impressions, but with perfect gland activity and a well-developed sympathetic nerve system, what pictures would accompany its sex discharges? How far could it go towards creating definite images? What this child could do would show the pulse forms as contrasted to the content due to sense impressions. We thus come to a problem akin to that of Kant. Thought would be a combination of pulse forms and sense data, but these forms would not be transcendental in origin, but the result of sex evolution. Each clear thought would be partly pulse and partly sense; the vital element would be in the one, the utility in the other. The elements of the dream are beneath our waking thought, but its sense content is so fully overlaid that the dream element is confused with the inflowing sense impressions. Though censored and depleted, the dream form exists and is the vital antecedent in all our thought. The nerves dominate, but they do not originate.

This view involves a type of thinking that is old, for it assumes there are native elements in mental activity not derived from the senses. Instead of a blank mind there are inherited mechanisms which determine the types of thinking. But these forms are not transcendental, nor do they need external stimuli to excite their activity. The forms of thought are independent of and antecedent to the concrete additions that come from sensory sources. The new view differs from the old in not starting from abstract concepts like space and time, but from concrete images due to sex and fear. Both sex and fear images are evoked by internal awakenings and not by external data. Here are origins of thought that heredity could create, and if they

are given the more abstract relations could be readily derived from them. It is customary to describe sex imagery as instinctive, but this is merely to name it without giving any explanation. Animals do things with precision for which they have no experience to guide them. Are they merely mechanical reactions or are these animals aided by a picture of the act by some inherited mechanism? Can they dream of what they are to do as men dream? Can they wish and thus anticipate events, or does some blind force drive them to their deeds? To give animals a dream life accords with what we know of our mental activity and breaks down a barrier between their thought and ours. Sex and fear are elements in all conscious life. Is it likely that the imagery they evoke appeared only in human beings? Is it not more probable that their anticipatory dream life is more specific than ours, and thus is more of an aid in the necessary acts on which their lives depend?

Be this as it may, certainly the wish with man goes before the act, and the wish in turn must have a visual antecedent by which it is aroused. These antecedents need not be definite. There is no need of having the power of throwing a beautiful woman on the mental screen to make sex wishes a force. But the elements of form and beauty must be there which slight additions from external sources make definite enough to direct sex wishes. Beauty is light and color attached to some object. But the origin of our concepts of beauty and worship shows simpler objects than woman first arouse our admiration. Men worship light, movement and color in their earlier religion and seek to identify themselves with these primal elements. They also worship a sun god before they are aware of a God of Justice. The light, the heat, the sound, the highly colored, the oval, the disk, the awesome, are early objects of appreciation. All these an inherited mechanism could form for us independent of sense impressions. The series in a sex dream may be thus described—first a bright spot, then a highly colored view which draws the observer to it by a magical force, the view becomes a landscape above the horizon of which the sun appears. The sun becomes a god, a hero, or some familiar form of super life. Memories, judgments, and censorships play a more effective part as the dream proceeds. And yet its course is fairly constant, and from it we can recognize the internal elements that through heredity antedate our sense impressions.

The path of a fear dream is equally clear. It starts with a dark spot or cloud which turns into objects of terror as they approach. Movement is suspended and vain endeavors to escape are made. Then comes a falling sensation. A bottomless pit

opens up, but before the bottom is reached the spell is broken and the dreamer awakes. Here we again have a series that an inherited mechanism could produce. As with sex dreams external elements are readily admitted into the picture and blended with it, but the essentials come not from external impressions but from internal sources. They represent discharges due to pressure, and not nerve reactions excited by external stimuli. It is not difficult to separate the effects of pressure discharge from nerve reaction if we once get the key to their explanation. The antecedent of the one is in the blood, while the other has its origin in the nerve cells. When the two blend we have conscious thought. They are isolated only in dream life.

If we think of consciousness as gland discharge we have a high or low threshold of consciousness as the pressure is great or less. The high pressure gives a bright coloring to our emotions, and from them the sex series starts which we interpret in terms of light, the sun, God, and beauty, with woman at the end of the series. The low pressure in contrast to this gives black spots and heavy moving lines. These become snakes, bears, dragons, demons, as we increase the indefiniteness of our interpretation. For several years I was troubled with dizziness and am therefore familiar with the elementary images due to a low threshold of consciousness. A slight attack makes external objects seem to whirl. With a worse attack heavy black lines fly about in the field of consciousness. These a diseased mind mistakes for snakes. If the attack becomes worse, darkness engulfs and an unconscious epoch follows. It is these dark pictures that we associate with evil. The bad is always pictured with heavy black lines, and thus seems hideous. In reality, however, it is the beautiful woman who is the tempter, while the homely woman is the saint. Could there be better evidence than this to show that our dream images are due to inherited mechanism and not to sense experience?

This proof can be carried a step farther by analyzing the content of the glands when pressure forces their discharge. If the content is toxic a low threshold of consciousness results, with the wiggley lines which readily turn into snakes and dragons. If the gland content is nutritive a high threshold results, with light, beauty, God, and woman. The two series flow from the two levels of consciousness, and each has an independent mechanism due to heredity. The two flows of conscious pulse intermingle in many ways, and out of this comes the complexity of emotion and thought. There are, however, four elementary movements, one of which can be recognized in any thought movement.

The simple movements are from light to sun, power, and sex, or from dark lines to snakes and demons. Changes, however, can be made suddenly from one level to the other, from which a complex movement results. The bad pictures may suddenly be changed to bright ones, and then we get the concept of hero, Saviour or Redeemer. Or the movement may start on the higher level and then dip down to the lower level. We then have a crisis out of which the thought of self-sacrifice comes. If we picture these in terms of gland activity any of these movements could readily result, and thus an explanation given that does not involve any mysterious elements. When we understand the transformations of the blood, the discharge of glands and the action of toxins and nutrins, each step can be readily followed and the antecedents of consciousness correctly presented.

If light has been thrown on the physical mechanism antecedent to emotion, the next step is to offer some explanation of the nature of a wish. Wishes are emotion directed to some sensory end. A wish is thus not pure emotion, but emotion mechanically directed to some object. Dr. Freud has been a great aid in separating wishes from pure emotion on the one hand, and from motor activity on the other. We must now ask whether wishes are to be regarded as a nutritive discharge or a nervous reaction. The best answer to this are our appetites. The mere sight of food arouses not merely a wish for food, but a gastric flow in the organs where food is digested. The gastric flow does not depend on food contacts, but on food wishes. If gastric flows and food wishes occur together, is it not a simpler explanation to say that the flow is the cause of the wish than to seek an independent origin for wishes? And if this type of wishes has gland discharges as its origin, need we look farther for the source of other wishes? A dream would then be a form of gland overflow, while the wish is the same discharge excited by external stimuli. The wish thus has a direction which dreams lack. Good dreams and good wishes have their origin in these pressure overflows. Bad dreams and depressing fears arise from some toxin in this discharge. The failure to discharge and the overflow start mental activity each of its own kind.

The same reasoning would explain why our dreams are wishes and why repressed action tends to become the content of our dream life. In action we drain the surplus flow from the glands aroused. A refusal to act leaves the glands of the repressed parts full to the point of overflow. We go to sleep with the dominant part of our waking selves drained of its surplus

while the repressed parts are full to overflow. Is it a wonder that when the drained parts are recovering their surplus in sleep that the unused parts should overflow and send our emotions along forbidden paths? The sleeping self reverses the waking self because the exhausted parts lose their dominance, and thus their power to censor.

It is not claimed that the preceding discussion has cleared away the difficulties of a rational explanation of consciousness, but it is hoped that a viewpoint is attained through making such a solution possible. Nerve psychology explains how consciousness is aroused rather than its physical antecedents. If the antecedent of conscious action is a discharge and not a nerve reaction; if it is a chemical change in the blood rather than an inherited nervous mechanism, the physical basis of consciousness can be traced through the steps from the intake of food to the result in action. The food becomes blood, and blood becomes nutritins or toxins. They accumulate in unused glands which discharge either through pressure or nervous excitation. These discharges arouse emotions which excite dreams if the discharge is through pressure, and conscious thought if the discharge results from some nerve stimulation. The nerves thus direct consciousness, but do not create it.

I have stated the contrast between the action of nerve and gland to bring out the elementary function of each. To ask whether the antecedents of consciousness lie in the sympathetic or sensory nerves would involve the same points as to ask its relation to glands and nerves. The sympathetic system controls gland action, while the sensory system directs motor action. The one represents life processes, the other those of adjustment. It is needless to ask what consciousness is or where is its seat. We can, however, learn what physical processes precede and what follow its appearance. This is what I mean by the track of evolution. Improvements start in economic changes reducing the cost of food, saving waste, and in increasing personal efficiency. A group of acquired characters is thus created which become inherited traits only by the slow process of physical evolution. The stomach, the blood, the gland, and the sensory nerve are gradually transformed into more effective means of promoting evolution. Through them we increase our knowledge of external processes from which new economies in food and greater personal efficiency result. In this way an economic theory of progress becomes a complement to current biologic theories, and together they give a clearer view of evolution than either in isolation presents.

SCIENTIFIC MANAGEMENT AND SOCIALISM

By MALCOLM KEIR

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APPARENTLY scientific management is as remote from socialism as the east is from the west, yet in reality there are few movements more effectual in promoting government ownership and operation of industry than the one fathered by efficiency engineers. Nothing could be further from the thoughts of the promoters of science in business, indeed, to many of them nothing could be more abhorrent, than the social reconstruction that logically completes their work; equally upon the other hand, socialists little dream of the powerful cooperation that will be given their aims by the men who are now attempting to reform business methods; nevertheless, the end of scientific management is socialism, for the one leads to the other in the evolution of industry. One route by which this end is reached is through the elimination of skill, another is by means of federal supervision of the foreign trade that arises as a result of the overproduction incident to the introduction of efficiency methods, and the third is the tendency that scientific management has toward installing automatic machinery, a trend that if carried to its logical conclusion—complete automatic production—would require government ownership. It is upon these three features of scientific management, namely, the elimination of skill, overproduction and the replacement of men by mechanisms, that we base our prophecy that scientific management leads to socialism. Since there are almost as many varieties of socialism as there are socialists, it should be understood at the outset that when that term is used we mean the government ownership and operation of the necessary means of production.

Scientific management has been welcomed by manufacturers because it places within their hands a new and powerful tool whereby the strength of skilled labor can be undermined and the power of employers strengthened. Ever since one man worked for another the interests of the two have been opposed in the struggle to determine wages, and a large factor in the favor of the workman has always been the skill he possessed and which the employer was forced to use, and to reward. As

long as production was simple, the recompense of any laborer was usually in proportion to the amount of skill involved in his job. The complexity introduced into production by the invention of machinery served to heighten the importance of this ancient rule, for although machines suddenly at one blow usurped a great amount of traditional skill, nevertheless, they did not eliminate entirely the employers' dependence upon skilled labor, with the consequence that under the mechanical *régime* ushered into industry by the industrial revolution, a man's wages more than ever depended upon the skill involved in his job. Where little or no special deftness was required the machine owner took almost all the proceeds of production, giving the laborer just enough to maintain existence. In the first flush of power in England, manufacturers went even further than this, for they paid workmen less than the exigencies of existence demanded, trusting to charity to make up the difference between wages and life necessities, a situation which was not relieved until the compulsion of national legislation and the demands of labor unions forced manufacturers to relinquish some of the advantages of their position. Highly skilled workmen, on the other hand, were able to demand and receive a share in the proceeds of production, greatly in excess of bare subsistence wages. Skilled workmen have a monopoly and as a result exert monopoly privileges; the extent to which they share in profits is determined by the degree of their monopoly.

Inasmuch as this citadel of labor prevents manufacturers from securing to themselves most of the gains of business, it stands as a constant challenge to them and spurs them onward to make every possible inroad upon their adversaries, by inventing and adopting devices which will eliminate the dependence upon skill; after years of assault of this character, although the band of men within the beleaguered fortress has grown smaller and smaller, the stronghold still maintains its integrity. *It is at this point that Scientific Management comes to the aid of machine owners, for it is virtually a new mechanism that transfers skill from the operatives to the operators, or from another point of view, it is one more step in the subdivision of labor whereby the power of workers is lessened and that of employers strengthened.*

In the past, methods of work or the manner of using a machine has been left largely to the laborers concerned, and manufacturers exercised little supervision over the exact way in which a man turned out any job. The men, unaided, developed

"rules of thumb" and secret practises satisfactory to themselves and also to the management, although the office did not know just exactly what went on in the shop. A considerable body of knowledge of this sort rested with the men and constituted a respectable portion of their "skill." Efficiency engineers set themselves the task of bringing this art under the control of the management; the first studies, therefore, were aimed at finding out just what the men knew about their jobs, and classifying, indexing and standardizing the information obtained. Then a first-class workman was studied minutely in every phase of his operations, and the motions, appliances and methods of his work analyzed to the last detail, and, finally, all the parts were synthesized into a new whole which was better than any operation ever performed by any man by himself. Thereafter, this new method of work became the standard of every worker in the plant, for no man was allowed to perform his task any longer just as he pleased, but was required to follow the rules laid down by the management; in other words, the management took over most of the "skill" and the men merely followed instructions. Scientific management, therefore, was a tremendous assault upon the bulwarks of skilled workmen, and after it began to function fully it actually permitted men of much less experience to carry out the duties which formerly required highly trained men; for instance, day laborers could be put on the more simple operations of machine work, formerly the job of well-paid machinists.

Yet, nevertheless, when first introduced, scientific management increases rather than decreases the laborer's share in the proceeds of production. Efficiency engineers gain by their analytic methods a greatly enhanced out-put with the same machines and the same labor. Of the profits which arise from the augmented product, the management usually takes two thirds and gives the men one third, a fair enough division, since part of the return may be considered as interest arising from the investment in the new "mechanism," and in addition since the men themselves did nothing to create the conditions under which alone the enlarged production was made possible. The one third share of the men so increases the wages of the workers over the customary pay for their particular class of labor that as a rule they are perfectly satisfied with the arrangement. Consequently scientific management is unlike any other innovation that has ever been introduced in industry, for all other improvements have borne harshly upon the workers immediately involved, although in the long run labor in general

was benefited; on the contrary, scientific management is advantageous to the workmen who are directly involved in it. Despite high wages, the production under scientific management is so greatly increased that the manufacturers gain a lower labor cost per unit than they formerly enjoyed; high wages in fact are granted to the men as an inducement to work faster, so that this desired output may be attained.

The secret of the success of efficiency engineering lies in the great unevenness of industry. Every step from management on the verge of bankruptcy to the most highly efficient may be found and every stage in industrial evolution from complete hand work done at home—the manufacture of women's neckwear, for example—to factory operation in which every process may be performed by machinery, as the shoe industry illustrates. *Scientific management brings profit to those few who adopt it because the great mass of their competitors is without it.* The price of the product is set by the cost of production found in the great number of plants of average efficiency. The scientifically managed plant with a lower cost of production than the average may do one of two things; it may lower its selling price so as to capture the whole market and make its profits by the quantity sold—after the manner of Henry Ford—or it may be satisfied with making a large profit on its smaller volume of sales by leaving the price where it is set by competitors. The second is the more usual method of procedure, because to run a very large business requires organizing ability of the highest and rarest kind, and, furthermore, the second method yields a comfortable profit without involving anywhere near as much work. However, the first method is the safer, for it gives a virtual monopoly when it is easy to acquire, since scientific management is like a machine, if it isn't "patented" and kept for one's own personal advancement, one's competitors will seize it, and hence eventually it will lose all strategic value to the first owner. If a manufacturer chooses to install scientific management and does not attempt to grasp the full monopoly privilege inherent in its possession, but uses it as he would any other piece of new equipment, he can make it pay handsomely as long as other men in the same line of business do not hire an efficiency engineer, but, just as in the case of any other mechanism, every competitor will be forced to adopt it eventually or go out of business. The profits that arise from the use of scientific management vary inversely with the number of users—to talk mathematically—hence *the increased production due to efficient methods will itself, in the long run, yield no financial returns.*

What then will become of the workman's extra wages? The answer is obvious; that, as the enlarged profits which permit bonus wages to be paid disappear, the additions to wages over and above the market rate will also vanish. The laborer will be worse off than he was in the beginning, because he will have sacrificed to a planning department belonging to the management his "skill," by which he forced high wages; and the pace at which he worked at first in order to gain extra pay will have become required without the greater compensation. Here then is the first place that scientific management will lead to socialism; the men working harder than ever, but witnessing a constant shrinkage in the contents of their weekly envelopes, yielding more and more of their traditional skill to the accurate studies of the "office" and seeing their jobs handed out to less and less trained men hired at lower wages, realizing that the employer is attaining ever greater right to the total income of production, the men will demand that the government regulate industry.

The first form such regulation will take will probably be a national minimum wage law. Once such a law is granted, it will be revised continually in order that the minimum may be raised to ever higher levels. The workers ought to be able to secure this boon in the face of the opposition of manufacturers, because the men will have the vote and can hold a political ax over congress. Massachusetts has long been acclaimed as a leader in industrial legislation whose object is betterment of labor, not because the state is any more enlightened than others, but largely on account of the fact that 50 per cent. of the people in gainful occupations are engaged in manufactures and all but 5 per cent. (4.9 in agriculture) of the remainder are more or less closely associated with the factory enterprises. The workers of the state, therefore, who are voters, have a close interest in labor laws and can force them from the legislature. Not only may the artisans of the future seek to enforce national minimum-wage laws but also they may endeavor to curtail production by lessening the hours of a work day, and make six or four hours the legal work period over the whole country. The profits of the manufacturers, already cut down by competition, will thus shrink further under the enforced higher wages and shorter hours, so, in some future crisis, when aroused labor makes greater onslaughts upon profits, the manufacturers themselves may be glad to sell their plants to the government under which they then may become managers with a salary.

The discontent that must eventually be felt by workmen on

account of scientific management may be translated into action such as we have noted, and the logical outcome of the movement of the workers against the efficiency of the managers seems to be government ownership and operation of industry—which state is synonymous with socialism. However, the manufacturers of the future may be shrewd enough to foresee this result and take measures to turn aside labor's dissatisfaction.

The scheme that most probably will appeal to employers as a way out of their difficulties is profit-sharing of some kind, even though the name and aim may be disguised under a different term. If the employees share in the profits of a business, that enterprise is socialized, and the first step toward more comprehensive socialism has been taken.

Likewise *any* device that may be adopted to appeal to laborers must have in it some germ of socialization, for otherwise the workers would disdain it. Hence any attempts manufacturers may make to soften the effects of scientific management only lead them into paths whose final goal is socialism.

The elimination of skill is by no means the only route by which scientific management leads to socialism, for not only do efficiency engineers strive to get rid of operations requiring skill, but they also bend all their energies toward increasing production. This fact gives rise to a set of forces which tend to operate in the direction of socialism.

Before the opening of the Great War, when few industrial plants were operated by efficiency methods the nation faced the necessity of a market abroad, because the mills had reached the point where their production just about filled domestic needs. The home market, therefore, was unable to absorb a surplus, with the consequence that foreign trade became most attractive to American producers. Into this situation we are now introducing scientific management, one of whose tenets is an increased output often double, sometimes triple the average of previous experience. Just as long as the new scheme of organization is limited to a few concerns, industry as a whole is little influenced by the augmented production, but, inasmuch as all concerns must eventually adopt scientific management, the nation is facing a future period when production as a whole will be at least two or three times what it is at present. The multiplication of products will tend to lower prices and thus broaden the domestic market, but it seems hardly probable that the home consumption can absorb the entire surplus, especially since the nation had already commenced to feel the effect of

glut, even before the operation of new methods of management influenced out-put. As a result, it does not take a very keen vision to predict that the United States must take an ever increasing interest in foreign trade, a movement that will precipitate an intense commercial struggle between nations for supremacy. In order to meet strenuous international competition, American factories must be so organized that they may be treated as a unit, and all wasteful practices—such as cross freight, unnecessary transportation of raw materials to plants poorly situated or needlessly long hauls for products destined for export—may be eradicated. These ends may be attained at first by government control, but regulation of industry will usually lead to ownership because mere federal methodizing will never prove entirely satisfactory. We have amply proved this in the case of railroads, for, beginning by loose regulation, federal authority over steam-railway transportation has been tightened constantly, until now even railroad presidents themselves declare that they see no relief in sight except such as may come through government ownership. In a similar manner the mere shadow of government, at first extended over foreign trade, will take on more and more substance until—as is the case with Germany—the state itself shall become the virtual dictator of foreign trade. In order to carry on its affairs satisfactorily, the government agencies in control of foreign traffic must reach backward inland to regulate the sources of production until individual factories come under its powerful sway, and then socialism will be here, although it may be called by some other name.

Starting with scientific management we have arrived at socialism a second time, but our story is not yet done, for there is a third condition that grows out of efficiency methods, and this third one, the increased use of automatic machinery, like the other two, is completed by socialism.

One of the foundations of scientific management is a study of the motions necessary for the carrying on of every process in the making of an article; it aims to simplify the motions continually in order that they may become most nearly mechanical. The next step, namely, adjusting the machine to give the mechanical equivalent of the motion instead of trusting to a man, is an easy one. Scientific management, therefore, greatly hastens the transferal of skill from men to mechanisms, and brings forward more rapidly the day when all machinery will be automatic.

It is not easy to accept this concept, for it seems like fly-

ing in the face of truth, yet we can see the tendency toward automatic machinery in every industry around us. Not many decades ago a weaver took care of just one loom, and the passing of the shuttle bearing the weft was a hand operation. One of the first improvements in looms was to kick the shuttle across the warp by a mechanical device and then power was applied to the whole operation of the loom. Later improvements augmented the number of shuttles from one to half a dozen, still later refinements threaded each one of the six shuttles automatically. Furthermore, when any thread breaks, the loom stops automatically and another machine worn on the weaver's thumb reknits the broken strand. Instead of requiring one weaver to each loom modern mills need only one for every twenty machines. It is not an idle dream to suppose that some day no men at all will be necessary for loom operation. Take another illustration from among a great number. To make a screw once required a man and a machine for each operation of heading, tapering, threading, slitting the head and cutting off, or one man had to readjust one machine five times for the five operations. To-day one machine—the turret lathe—performs all five with one adjustment and in addition feeds itself with raw material. As a result, one man can take care of ten screw machines. Is it impossible that some day that one man will not be needed?

Many people will accept the eventual automatic production of all products whose processes require mechanical repeated motions, but to them it seems incredible that machinery can ever displace men entirely, because so many operations as now conducted necessitate judgment, a faculty no machine can acquire. Nevertheless, for every action that demands judgment, there is some mechanical equivalent that will bring about the desired result. For illustrations, we are familiar with the perforated paper roll that plays pianos, the wax record that does the work of stenography, or the mathematical combination of gears that adds, subtracts and multiplies. There may be a small irreducible minimum of labor essential say for the starting and stopping of machinery, but the great mass of labor will be set free.

This stage of industry will be coming to the front rapidly in the days when scientific management is universally adopted, for efficiency engineers bend their energies constantly toward making motions simpler, easier and more mechanical in nature, and then replacing the man by a cam or a gear which performs the action better than any man could. Scientific management,

therefore, greatly promotes the use of automatic machinery. It is clear then that as the tenets of efficiency engineers are accepted by all manufacturers and as, through the engineers' studies, machinery more and more completely ousts men, that the profits of industry will go to the owners of machines even more fully, until, if allowed to go to the logical end, *capitalists will absorb all the proceeds of production because there will be no factory laborers*. To place the control and the emoluments of industry in a few hands, because the few have the money to purchase the needed automatic machines will frighten people for the reason that the few could exercise a terrible power over the many; therefore, the many will insist that the automatically operated industries be owned by the government or in other words by themselves. This means socialism.

The government ownership and operation of industry—or in other words, socialism, therefore, grows out of scientific management by three different branches. Inasmuch as scientific management tends to eliminate skill, it may come about that labor will try to retain its hold on high wages through government interference with industry; furthermore, since scientific management goes in the direction of over-production, the United States must become an exporter and, in order to compete, the government must control and perhaps endeavor to make operations as simple as possible, and when it attains the desired simplicity, change the operator from a man to a mechanism. If this tendency ever becomes a universal fact—that is, all industry conducted by means of automatic machinery, the government will be forced to own and operate industry because to place such power in private hands would be too dangerous. Because scientific management as a movement is yet young, it is worth while to make this examination into its tenets and to point out its tendencies, for our attitude toward it can then be based upon reasonable ground. If you favor socialism you ought to uphold scientific management, but if socialism is a nightmare to you, then you should condemn this new industrial revolution. It makes little difference whether or not you are pleased with scientific management because it is in industry to stay, for the same reason that machinery has been maintained; it is the most efficient method of production. Since it is economic it must become universal, and when it is everywhere employed some degree of socialism must prevail.

FAMILIES OF AMERICAN MEN OF SCIENCE

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III. VITAL STATISTICS AND THE COMPOSITION OF FAMILIES

IT has been claimed that children of older parents are physically and mentally inferior. Conversely, C. L. Redfield in a curious book entitled "Control of Heredity" and in various articles argues that men of distinction are likely to be born when their fathers are old and that their performance is due to inheritance of the experiences gained by their fathers. If the age of the parents affects the constitution of the children, this clearly is a matter of importance, particularly if the principles of eugenics are enforced either by law or by sentiment. But at present we have no scientific information on a problem which could be solved by statistical research.

The fathers of 865 leading American men of science were on the average 35 years old and their mothers were 29 years and 8 months old when their sons were born. The fathers married at the average age of twenty-eight years, being somewhat more than five years older than their wives. The scientific men are consequently born at an average interval of seven years after the marriage of their parents. The ages are given separately for the four groups into which the scientific men have been divided and are earlier for both fathers and mothers (group I. in the table) of those more distinguished. The probable errors given in italics show that the differences may be due to chance, but that this is unlikely. It is the case, as shown

TABLE XII. THE AGES OF THE PARENTS AT THE BIRTH OF THE SCIENTIFIC MEN AND AT DEATH, ACCORDING TO THE STANDING OF THEIR SONS

	No.	Age at Birth of Scientific Man		No.	Age at Death	
		Father	Mother		Father	Mother
I.	64	34.02 \pm .57	28.37 \pm .50	62	70.18 \pm 1.12	70.89 \pm 1.36
II.	160	34.54 \pm .40	29.86 \pm .31	154	70.85 \pm .75	70.68 \pm .78
III.	505	35.00 \pm .23	29.72 \pm .20	496	70.77 \pm .38	69.96 \pm .36
IV.	136	35.69 \pm .53	30.09 \pm .38	121	70.91 \pm .92	69.45 \pm .99
Total	865	34.95 \pm .18	29.70 \pm .15	833	70.64 \pm .80	70.20 \pm .31

below in Table XIV., that the first-born son is the one most likely to become a scientific man, and the parents of first-born children are of course younger.

In Table XI. is also given the average age at death of the parents, whence it appears that the fathers died at the average age of 70.6 years, the mothers at 70.2 years, the chances being even that these figures are correct within a third of a year. The average age of the scientific men being about fifty years, most of their parents are no longer living. If, however, the deceased parents only had been included, the averages would have been too low, as the more long-lived parents would be those more likely to be living. The expectation of life has been added to the age of each of those still living, and the probable age at death used in the averages. The ages given do not mean that people of this class live to those ages, or that the men live longer than the women. A statistical error such as this has often been made, a distinguished scientific man having, for example, urged that it is one of the advantages of the scientific career that scientific men live much longer than the average, failing to note the circumstance that there are no scientific men who die when they are babies. The figures in the table mean that the fathers being on the average 35 years old when their sons are born have an expectation of life of 35.6 years, and will on the average die at the age of 70.6 years. The mothers, averaging 29.7 years old, have an expectation of life of 40.5 years. These expectations are about four years longer than those allowed by standard mortality tables, but the data are not exactly comparable. Although the parents of the more distinguished scientific men do not live longer than the others, they live longer after the births of their sons.

TABLE XII. THE AGES AT DEATH OF THE FATHERS OF THE SCIENTIFIC MEN IN ACCORDANCE WITH THEIR OCCUPATIONS

	No.	Age at Death
Professions....	370	69.67 \pm .45
Clergymen	94	71.68 \pm .81
Physicians	66	67.20 \pm 1.08
Lawyers ...	57	71.75 \pm 1.19
Teachers...	70	69.29 \pm 1.67
Other.....	83	68.25 \pm .92
Agriculture...	193	72.81 \pm .62
Manufacture	330	70.65 \pm .48
Total.. ..	893	70.71 \pm .29

Table XII. shows that the farmers who were fathers of scientific men died at the average age of 72.8 years, the physicians at 67.2 years, a difference of over five years between the shortest and longest lived of the groups. The clergymen and lawyers lived one year less than the farmers, the teachers two and a half years less. Those engaged in manufacturing and trade died at the average age. According to the report of

the English registrar-general (1908), the death rates per thousand during the years 1900-1902 for those between 45 and 65 in different occupations were: Farmers, 14.8; clergymen, 15.5; teachers, 15.8; lawyers, 18.3; physicians, 23.9.

Table XIII. gives the ages at death of the mothers in accordance with the size of their families. The crude figures are sub-

TABLE XIII. AGE AT DEATH OF MOTHERS OF THE SCIENTIFIC MEN IN ACCORDANCE WITH THE SIZES OF THEIR FAMILIES

Size of Family	1	2	3	4	5	6	7	8	9	10	11	12	Av.
Number.....	45	91	106	136	110	112	59	44	27	16	8	5	759
Age at death..	61.7	67.9	69.3	71.7	69.1	71.5	73	70.7	77.6	70.5	76.2	80.6	70.1
No. dying under 45.....	10	17	11	10	11	3	2	4	0	0	0	0	68
Age at death of those surviving 45....	68.6	74.2	73	74.4	72.5	72.5	74	73.6	77.6	70.5	76.2	80.6	73.3

ject to a statistical error, as mothers might have small families because they died early. This is eliminated by considering only those who survived the child-bearing age. In this case mothers of one child died at the average age of 68.6 years; mothers of 12 children at the age of 80.6. There are included 759 families, but the number of families of different sizes is too small to give entirely valid averages. Still it is significant that the thirteen mothers of 11 and 12 children lived to the average age of 78 years; the 43 mothers of 9 and 10 children to the age of 75 years. It is probable that the women who were the more vigorous had the largest number of children and also lived to the greatest age; they might have lived as long or even longer if they had been unmarried. Though largely due to statistical selection, the fact remains that of 45 mothers of one child 10 did not survive the age of 45, whereas of 56 mothers of from 9 to 12 children not one died under this age. In view of these facts it may be doubted whether the practise of limiting the number of children is beneficial to the health and longevity of the mother.

Table XIV. gives the numbers of scientific men who were first-born children, second-born, etc., for each size of family. A scientific man is of course more likely to be a first-born child than a second-born, because there are families with only one child and consequently more first-born children. But it appears from the table that the first-born child is more likely than the others to become a scientific man. In families of two or more children, 285 are first-born and only 168 second-born; in fami-

lies of three or more, 214 are first-born and 114 third-born; in families of four or more, 159 are first-born and 81 fourth-born.

The first-born child has been reported to be more likely to be a man of genius, an idiot, a consumptive and various other

TABLE XIV. THE ORDER OF BIRTH OF SCIENTIFIC BORN

Order of Birth												
	1	2	3	4	5	6	7	8	9	10	11	12
1	63											63
2	70	52										122
3	55	39	31									125
4	53	33	32	29								147
5	47	13	18	17	23							118
6	30	17	16	19	21	14						117
7	16	7	8	7	9	14	7					68
8	7	3	5	4	8	5	4	8				44
9	5	1	2	4	4	4	0	3	5			28
10	1	1	2	0	1	2	0	0	0	5		12
11	0	1	0	1	0	1	0	0	1	1	1	6
12	0	1	0	0	0	0	0	1	0	1	1	5
	347	168	114	81	66	40	11	12	6	7	2	1 855

things, but usually as the result of some statistical fallacy. If, for example, in our figures only families of two and eight are considered, there being on the average five children and two first-born, it looks at first sight as though the chances are one in five that an individual selected at random would be the first-born. But both families being represented,

it has been argued that the chances are half that the individual is the first-born in the small family and one eighth in the large family, or on the average five sixteenths, nearly one in three. However, the family of eight is four times as likely to be represented in a random selection from the two families, so the chances of the individual being first-born are reduced to one in five. Finally—and this seems to have been overlooked—there are three times as many families of two as of eight, and there are in fact 16 chances out of 61, or a little over one in four, that the individual selected at random will be the first-born.

These errors have been eliminated by the method used in the table, but there are at least two other statistical errors that affect such data. When we are dealing with contemporary families the older children may be preferred. Thus children under fifteen are not likely to suffer from pulmonary tuberculosis or to be criminals, and the patient or the prisoner may be more likely to be the first-born child than the last born. This circumstance holds for the scientific men. They are on the average 38 years old when they attain their position, and the scientific population is rapidly increasing, so the earlier born children are more likely to be included. This factor, however, is small, as is shown by the fact that the second-born child is not appreciably more likely to be a scientific man than those

later born. Probably a larger statistical error is introduced by the fact that a man sometimes does not know of or ignores children who were born and died before he himself was born, and thus records himself as the first-born.

In so far as it may in fact be the case that the first-born child is more likely to be a scientific man, this is probably due to social rather than to physiological causes. Galton found the eldest son to be preferred, and perhaps this might be expected under a system of primogeniture. In this country where families are apt to improve their economic condition, the younger sons may be more likely to be sent to college than the older, but as to this there is no available information.

In Table XV. the intervals are given between marriage and the birth of the first child and between the births of successive

TABLE XV. INTERVALS IN YEARS BETWEEN MARRIAGE AND BIRTH OF FIRST CHILD AND BETWEEN BIRTHS OF SUCCESSIVE CHILDREN

Size of Family	No.	1	2	3	4	5	6	7	8	9	Av.
1	70	3.17									3.17
2	121	2.14	4.21								3.17
3	120	1.87	3.09	4.00							2.99
4	56	1.59	2.40	3.16	3.82						2.74
5	29	1.62	2.52	2.69	3.38	3.76					2.79
6	12	1.33	1.83	2.00	2.92	2.25	2.75				2.18
7	5	1.40	2.00	1.60	2.60	3.00	2.00	2.20			2.11
8	2	2.00	1.50	2.50	2.00	2.00	2.00	2.00	3.50		2.19
9	1	1.00	2.00	1.00	2.00	2.00	1.00	3.00	2.00	2.00	1.78

children for families of different sizes. When there is only one child it is born on the average 3.2 years after marriage, whereas in a family of five or more the interval is about a year and a half. In the standardized family of two the second child is born 4.2 years after the first, twice as long as for large families. The delay in the birth of children in small families might be due to the same physiological or pathological causes which make the family small, but in most cases it is probably due to voluntary control.

From Table XVI. it appears that 478 scientific men had 716 sons and 660 daughters. This difference falls within the limits of chance variation, and is not likely to be significant. In the families from which 832 scientific men come there were 2,537 sons and 1,527 daughters. This disparity may at first strike the reader as inexplicable. Galton in his "Hereditary Genius" says: "I also found the (adult) families to consist on an average of not less than $2\frac{1}{2}$ sons and $2\frac{1}{2}$ daughters each. Consequently each judge has on an average of $1\frac{1}{2}$ brothers and $2\frac{1}{2}$

sisters. . . . 100 judges are supposed to have 150 brothers and 250 sisters." Nearly all those whom I have questioned about this statement think that it is correct. It seems to most people

TABLE XVI. DISTRIBUTION OF SONS AND DAUGHTERS

Size of Family	No. of Families	Family of Parents		
		Sibs	Sisters	Brothers
(1)				
2	126	126	69	57
3	128	256	123	133
4	152	456	244	212
5	125	500	266	234
6	123	615	327	288
7	71	426	235	191
8	48	336	172	164
9	31	248	121	127
10	16	144	83	61
11	7	70	34	36
12	5	55	31	24
Total	832	3232	1705	1527
Family of Scientific Men				
		Children	Sons	Daughters
1	81	81	42	39
2	136	272	153	119
3	130	390	199	191
4	63	252	130	122
5	41	205	104	101
6	15	90	46	44
7	5	35	16	19
8	4	32	10	22
9	3	27	16	11
Total	478	1384	716	668

obvious that if there are equal numbers of boys and girls, a boy must on the average have one more sister than brother. As a matter of fact, however, a judge, a man of science or any other man, is likely to have not fewer but more brothers than sisters. 832 scientific men had 1,705 brothers and 1,527 sisters. Havelock Ellis finds 121 boys and 100 girls in the families producing British men of genius, and concludes that they "are the offspring of predominantly boy-producing parents"; this curious fact is further emphasized by the fact that families yielding women of genius "show a predominantly girl-producing tendency." A boy has as many brothers as sisters, owing to the sex composition of families.

Thus in families of two, one fourth of the families will consist of two boys, one fourth of two girls and one half of a boy and a girl. On the average, four boys will have among them two brothers and two sisters, and there is a similar equality for larger families. A man is likely to have more brothers than sisters for the same statistical reason that he is likely to come from a larger family than he has. If a family consists of six boys, it is six times as likely to produce a judge as a family consisting of one boy and five girls. The judge or the scientific man is thus likely to have more brothers than sisters.

Table XVII. contains information in regard to deaths in the families of scientific men. For their brothers and sisters the percentage of deaths recorded under five years is 14.8, and under twenty-five years it is 22.5. For their children the percentages are 7.5 and 10.9. The death rate has thus decreased to half in a single generation, and for the children of the scien-

tific men is probably the smallest known. As only completed families are considered, there are practically no children under five, but those under twenty-five who might die before reaching that age make the death rate too low in this group. It is difficult to see how more valid statistics can be obtained than those supplied by scientific men, the order of birth and the dates of birth and death having been given; yet it is undoubtedly the case that all deaths are not recorded, especially for the brothers and sisters who died in infancy. This error would, however, only emphasize the decrease in the deaths of the children as compared with the preceding generation. The number of deaths among a thousand children born is not directly comparable with death rates per thousand of the child population. When there are seventy-five deaths under the age of five among a thousand infants born to the scientific men, the annual death rate is somewhat larger than 15.

The decrease in the infantile death rate in recent years is so remarkable as to be almost incredible, and the existing differences in nations and social classes are appalling. In the families from which our scientific men come, the death rate for children under five is somewhat over 30 and in their own families it is somewhat over 15. The rate in the registration area of the United States in 1900 was 51.9. In the present registration area it was 32.9 in 1911, varying from 41.1 in Massachusetts to 18.6 in Washington, from 74 in Fall River to 22.4 in Seattle. In or about 1900, the rates for other nations were:

Russia	134.5
Spain	104.1
Austria	86.7
Germany	74.2
Italy	74.8
England	53.5
France	47.6
Sweden	37.5
New Zealand	23.2

TABLE XVII. DEATHS IN THE FAMILIES OF SCIENTIFIC MEN

	Size of Family		Tot. or Av.
	Brothers and Sisters 1 to 6	7 to 12	
Number of families.....	515	129	644
Brothers and sisters....	1406	917	2323
% of deaths under 5....	14.22	15.59	14.77
% of deaths under 25..	22.28	22.63	22.51
Children			
	1 to 4	5 to 9	
Number of families.....	416	67	483
Children	1024	381	1405
% of deaths under 5....	7.37	8.01	7.54
% of deaths under 25..	10.69	11.55	10.93

The table indicates a small selective death rate against the

larger families. When there were one to six brothers or sisters the percentage of deaths under five years was 14.2 as compared with 15.6 for larger families; when the number of children was four or less, the percentage was 7.4 as compared with 8 for families of five or larger. This small difference is probably due to the coinciding decrease in the birth rate and in the death rate. The larger families had a higher death rate not because they were larger but because they were earlier when the death rate was higher. Other statistics, such as those of Rubin and Westergaard for Copenhagen, show a selective death rate against the larger families. In the statistics with which we are concerned poverty and neglect are almost excluded.

In Table XVIII. is shown the relation between the size of the family from which the scientific men come and the size of

TABLE XVIII. THE RELATION BETWEEN THE SIZES OF FAMILIES OF THE PARENTS OF SCIENTIFIC MEN AND THE SIZES OF THEIR OWN FAMILIES

	1, 2, 3	Size of Parents Families		10, 11, 12	Tot. or Av.
		4, 5, 6	7, 8, 9		
Under 50.	94	110	37	12	253
Size of family.	1.69	1.99	1.81	2.41	1.88
50-59.	74	93	33	5	205
Size of family.	2.35	2.14	2.69	2.60	2.32
Above 59.	43	61	31	4	139
Size of family.	2.60	2.77	2.48	4.00	2.70
No. of families.	211	264	101	21	597
Av. size of families.	2.11 $\pm .11$	2.22 $\pm .07$	2.30 $\pm .13$	2.76 $\pm .29$	2.22 $\pm .06$

the family that they have, the scientific men being divided into three age groups. It will be noted that the size of family of the scientific men varies with their age at the time, being 2.7 children when they are above 59; 2.3 when they are between 50 and 59, and 1.9 when they are under 50. These differences are partly due to statistical selection, the families of the younger men being not absolutely complete, and the barren and smaller families being more likely to be included. They, however, in part represent the declining birth rate within a period of twenty years. There is shown a slight positive correlation between the number of brothers and sisters and the number of children. Thus when a man comes from a family of 1, 2 or 3 children, his family averages 2.1, and as the size of the family from which he comes increases by groups of three, his own family increases to 2.2, 2.3 and 2.8. The probable errors show that the figures have a limited validity. The differences, how-

ever, may be due to the decreasing size of family, the older scientific men having larger families and coming from families which were larger because they were earlier. The inheritance of physiological fertility would depend partly and perhaps chiefly on the female, and the size of the modern small family is determined in the main by social and psychological causes. If the data here given were valid, they would show a slight correlation of fecundity in successive generations and a slight selective death rate against the larger family, which about balance each other. These conditions are those which must obtain in a state of nature, for unless there is a change in the environment, the number of individuals of a species can not considerably increase, and if they regularly decrease it will be exterminated. The relations which obtain in the families of scientific men are, however, probably due entirely to the decreasing death rates and birth rates of the past seventy-five years.

In Table XIX. the scientific men are divided into four groups in accordance with their distinction and the size of the family from which they came and which they have is given for each degree of distinction. The most distinguished group (I. in the table) came from

TABLE XIX. THE STANDING OF SCIENTIFIC MEN
AND THE SIZE OF FAMILY

	I	II	III	IV	Tot. or Av.
Parents' family					904
No. of families	71	162	530	141	4.64
Average size...	4.73	4.59	4.69	4.45	
Own family					554
No. of families	49	111	298	96	2.22
Average size...	2.50	2.17	2.14	2.39	

both cases above the average. The eminent man is slightly more likely to have more brothers and sisters and appreciably more likely to have more children than his colleagues. The most eminent group is, however, about five years older than the others, and this about accounts for their larger families, so rapid has been the decline in the birth rate. The lack of correlation between the distinction of a scientific man and the size of his parents' family may be due to a combination of causes. On the one hand, the only child or the child from a small family may be more likely to have educational opportunities or inherited wealth; on the other hand, he may have inferior heredity and opportunity for forming character.

The conditions are similar for scientific men who are unmarried or who have no children or but one, as compared with scientific men with larger families. There is but slight differ-

ence in their performance. The similarity may be due to a balance of various conditions, and is also in part accounted for by the fact that men marrying at the average age of 29.5 years have in large measure had such original ideas as they may hope to have and have in the main determined their careers. As a matter of fact those who are unmarried furnish fewer men than the average to the two more distinguished groups while those with six or more children supply a larger number. If the figures for scientific men with the largest families could be regarded as valid, it would be indicated that they are the ablest and most successful, but at the same time furnish the largest share to the group who have dropped out of the first thousand, perhaps owing to the circumstance that scientific work must be neglected to support the children. But the differences are too small and the families are too few to permit any conclusions except that under existing conditions there is no appreciable correlation between the distinction of a scientific man and the size of family from which he comes or which he has. This fact itself is, however, of considerable social significance. The material handicap of the larger family is balanced by improved character and greater efforts or by the superior quality of the men coming from and supporting the larger family. In his study of "Heredity in Royalty" F. A. Woods finds that there is a direct correlation between intellectual and moral qualities and between moral qualities and size of surviving family. In this case the larger family is not a burden for the parents. It is reasonable to assume that if the cost of children could be borne by society for whose benefit they exist, there would be larger numbers of children having superior inherited ability.



PAUL PAINLEVÉ.

The Distinguished Mathematician, now Premier of France.

THE PROGRESS OF SCIENCE

FRENCH CONTRIBUTIONS TO SCIENCE

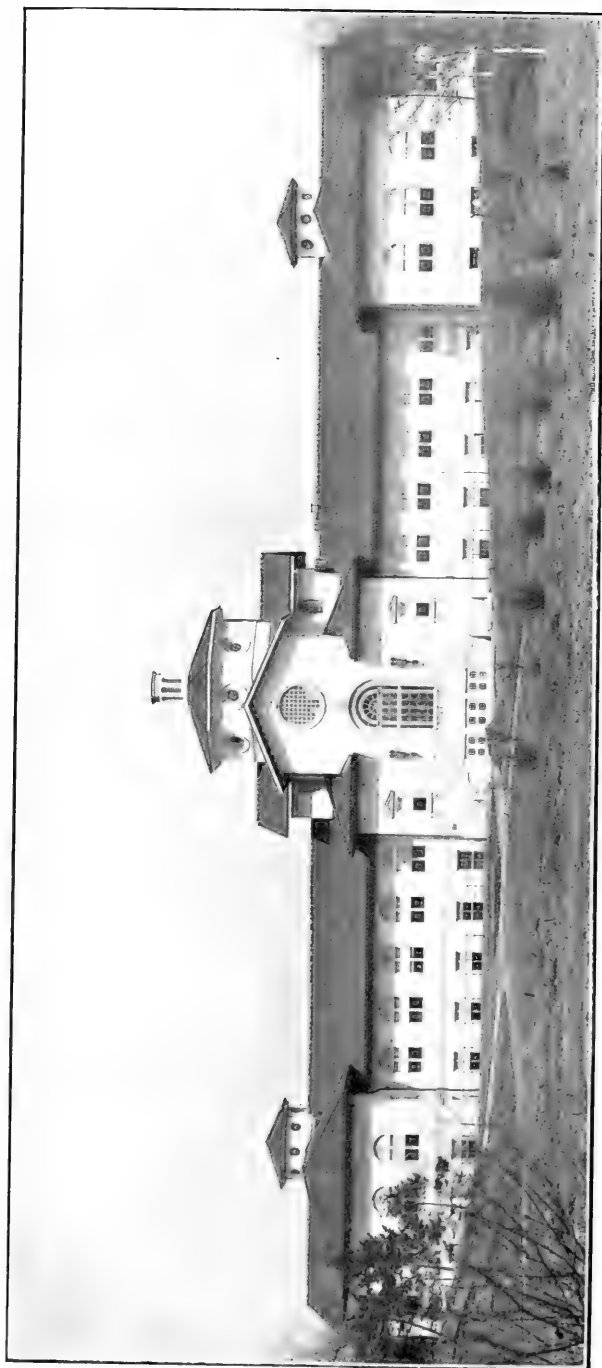
M. PAUL PAINLEVÉ, professor of mathematics at the University of Paris and of mechanics at the Paris Polytechnic School, has become premier of France in the present national and world crisis. Like M. Ribot, whom he succeeds, and M. Poincaré, the President of the Republic, who called on him to form the cabinet, he had been minister of public instruction. It is a curious commentary on our democracy that education is not represented on our cabinet, also that we do not have ministers of state, but only secretaries, named by the President to do his will. M. Ribot is a member of the French Academy. M. Poincaré is also an author of distinction and bears a name which has been made even more eminent in mathematics than Painlevé's by his cousin, Henri Poincaré, perhaps the greatest of modern mathematicians, and by his brother, Lucien Poincaré, the well-known physicist and mathematician.

M. Painlevé became a deputy only in 1914. Previously he was known as one of the group of mathematicians which made Paris the leading mathematical center of the world, including among its members Poincaré, Darboux, Jordan, Picard, Appell, Goursat, Hadamard and Borel. Mathematical analysis is a natural product of the clear and logical intellect of the French; it is of interest that it should be applied to the conduct of affairs of state. France is the most highly civilized of the nations and has used most freely men of scientific and intellectual parts in its government. But a highly organ-

ized and centralized civilization has the defects of its qualities. It remains to be seen whether the control by English gentlemen—represented by men such as Mr. Asquith, Mr. Balfour and Earl Grey, or the control by intellectuals, such as M. Ribot, M. Poincaré and M. Painlevé, will longest resist the flood of socialistic democracy.

There has recently appeared under the auspices of the Society for American Fellowships in French Universities a book entitled "Science and Learning in France" intended as a national homage offered from the universities of America to the universities of France. The work is edited by Dr. John H. Wigmore, professor of law in Northwestern University, and was prepared by distinguished authors representing different departments of science and scholarship. There is also printed a list of sponsors, nearly a thousand in number, professors in American colleges and universities, who in numbers and in contributions to science and scholarship compare favorably with names which could be selected for France or any other country.

President Eliot, in an introduction entitled "The Mind of France," calls attention to the cordial appreciation of intellectual achievement and particularly of scientific investigation by the French people. They have always placed high among their national heroes their great scholars, authors and men of science. American students, planning to study in Europe, have sometimes supposed, judging from certain aspects of Parisian life, that the French are an inconstant, pleasure-loving, materialistic people. The great mass of the



THE LABORATORY BUILDING OF THE BROOKLYN BOTANIC GARDEN.

people are constant to great political and social ideals, intelligent and devoted to family, home and country. Dr. George E. Hale, the astronomer, and at present chairman of the National Research Council, writes on the intellectual inspiration of Paris, giving special attention to the work of Louis Pasteur. These introductions are followed by a series of articles beginning with anthropology, archeology and astronomy, and taking up in alphabetical order the main departments of science and scholarship. Each of the articles gives a brief description of French contributions to the subject, with special reference to the contemporary conditions at Paris and the provincial universities. There is finally given a full account of the educational advantages for Americans in France; a history of the recent changes in the university system; an account of the institutions of higher learning, their organization, degrees, requirements, fees, etc., and practical suggestions to students intending to take up graduate studies in France.

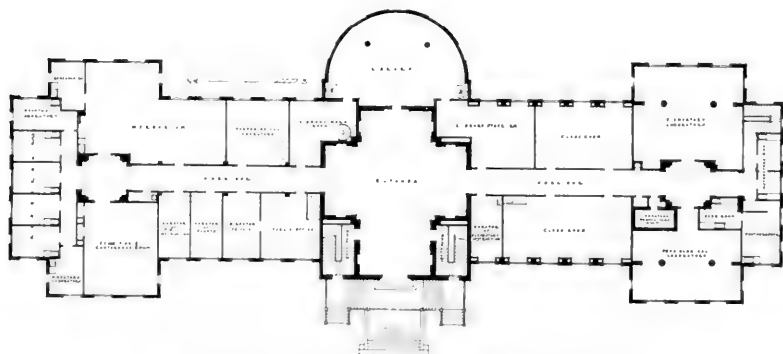
The great majority, probably more than nine tenths, of American students who have taken up work in foreign universities have done so in Germany. The universities of France and Great Britain have been too much neglected. In recent years the

great development of American universities and the practical opportunities, offered by fellowships and promotion to positions have led most students to remain at home. It is, however, extremely desirable that there be a free exchange of students between our universities and those of the great European nations.

THE BROOKLYN BOTANIC GARDEN

THE completed laboratory building and plant houses of the Brooklyn Botanic Garden have been dedicated with addresses by Prof. John Merle Coulter, officials of the City of New York, of the Brooklyn Institute of Arts and Sciences, of which the garden is a department, and by the director of the garden, Dr. C. Stuart Gager. Scientific sessions were held on two days, papers were read by thirty-nine botanists representing twenty institutions.

An article on the initial development and plans of the garden appeared in *The Popular Science Monthly* for April, 1912. Since that date the grounds have been enlarged by the addition of about ten acres, bringing two of the entrance gates directly opposite stations on the new subway lines, thus making the garden one of the most easily accessible of the numerous scientific institutions in Greater New York. The



MAIN FLOOR PLAN OF THE LABORATORY BUILDING.



IN THE BROOKLYN BOTANIC GARDEN.

completion of the laboratory building and plant houses, at a cost of over \$285,000, was made possible by a private gift of \$100,000.

In planning the building and grounds, and the character of the conservatory collections, there has been constantly kept in mind the broad aims of the garden, as tersely expressed by the phrase, "the advancement of botany and the service of the city." A scientific institution, supported in part by public taxation, not only enjoys opportunities, but has certain definite obligations to make direct returns to the community that supports it. The science of botany must not only be advanced by research, but the fruits of investigation should be interpreted to the general public in a reliable manner, and in terms that laymen can understand. Nothing hampers the financial support of scientific research more than the ignorance of the general public as to its nature and its value to mankind.

The plantations comprise the following sections: systematic, local flora, morphological, ecological, evolution and plant breeding, economic, and formal and other special sections. The unique feature of the

systematic section, occupying about five acres, is the combination of the herbaceous garden with the fruticetum. Beds of herbaceous plants are grouped in orders, and each ordinal group is enclosed by a planting of the shrubs botanically related to the plants in the beds. The educational value of such an arrangement is very great, making it possible to bring out relationships and contrasts not possible where the fruticetum is developed as a feature apart.

The local flora section has proved to be of great popularity, and has been a valuable factor in the propaganda for the preservation of our native wild flowers. Among the special garden features may be mentioned the Japanese garden (pronounced by Japanese critics as the finest garden of its kind in a public park in America), and the rock garden, the only garden of its kind accessible to the general public in Greater New York, and one of a very few public rock gardens in the United States.

The conservatory collections are developed along two lines—systematic and economic. The economic house has been especially appreciated by local schools in connection

with their nature study and geography. Provision is made for a mushroom cellar, for the display of both edible and poisonous species; and there are four cases for liverworts, mosses and filmy ferns. One range of greenhouses is devoted to the elementary instruction of children, and the classes for the preparation of gardeners and garden teachers. One plant house is devoted to investigation.

The north end of the laboratory building, and a portion of the south end, are planned primarily for the accommodation of research. In this work special emphasis will be laid on the experimental phases of botany, including physiology, genetics and pathology. There are eight private research rooms, four general laboratories, a sterilizing and culture room, two class rooms, herbarium, library, experimental dark room, photographer's suite, a children's room, and a lecture hall seating five hundred and seventy. Offices of administration occupy a portion of the main floor.

The scientific staff at present numbers eight, of curatorial rank, with one resident investigator and one research fellow. The garden publications include an administrative quarterly (the *Record*), *Contributions*, a series of popular *Leaflets*, *Seed List* (annual), and the *American Journal of Botany*. The latter is published in cooperation with the Botanical Society of America. The first number of a series of scientific Memoirs is now being edited for publication.

In the way of serving the local community it may be mentioned that according to the *Sixth Annual Report* of the garden, over 14,000 children and adults attended regular garden classes, in addition to over 8,500 pupils from local schools who visited the garden with their teachers under the guidance of a garden

docent, and also in addition to nearly 6,500 who attended public lectures.

As an illustration of one kind of service that botany can render in the stress of war, attention may be called to the fact that a large portion of the Botanic Garden grounds have, this year, been temporarily devoted to war gardens. Over 400 individuals are now cultivating these gardens, the individual plots varying in size from 8×10 feet to 20×40 feet. The garden has also assumed responsibility for starting and inspecting, during the growing season, over one hundred vacant lot gardens in Brooklyn, varying in size from a city lot to several acres. The entire time of one gardener, so far as needed, has been devoted to this work, and thousands of copies of popular pamphlets have been distributed on various phases of gardening, garden pests, preserving the surplus crops, and other related topics.

In short, the Brooklyn Botanic Garden has sought at every point to do two things: (1) to be directly useful to the community that supports and fosters it; (2) to advance and diffuse a knowledge and love of plants. Experience has shown that each of these lines of activity reacts favorably upon the other. The extension of the scientific work is contingent only upon an adequate endowment for that purpose, for, while the city largely (but not wholly) meets the annual cost of maintenance, the garden is chiefly dependent upon private funds for investigation and publication.

SCIENTIFIC ITEMS

WE record with regret the death of Adolf von Baeyer, professor of chemistry at Munich, distinguished for his work on synthetic indigo and in other directions, and of Eduard Buchner, professor of chemistry at

Würzburg, who died from wounds while serving as major at the front. Dr. Buchner was distinguished for his work on the chemistry of fermentation, and was the recipient of the Nobel prize for chemistry in 1907.

A NEW pedestal for the bust of John Muir has been made at the University of Wisconsin to be placed in the Building for Biology, where the bust of Muir was recently unveiled. The pedestal bears the inscription:

JOHN MUIR, 1838-1913

AUTHOR, EXPLORER, NATURALIST

A PRIEST AT NATURE'S SHRINE.

THE President has ruled that medical students and hospital internes who are drafted may be discharged from the national army to enlist in the Reserve Corps of the Medical Department and will be permitted to complete their medical course. By order of the surgeon-general the following letter has been written to the editor of this journal: "In reply to your communication of August 15 requesting information relating to drafted men who possess scientific training, I beg to advise you that the Sanitary Corps of the United States Army, attached to the Medical Department, will accept a number of selected men who are not phy-

sicians, but who have attained professional standing in bacteriology, chemistry and the several branches of engineering pertaining to sanitation. The Corps was organized specially to secure the services of skilled sanitarians having experience in both practical field work as well as those specially qualified in the several scientific branches having a correlation to the sanitary sciences."

THE Nitrate Supply Committee, appointed by the Secretary of War, has recommended that contingent upon satisfactory arrangements with the General Chemical Company, out of the \$20,000,000 nitrate supply appropriation such sum as may be needed, now estimated at \$3,000,000, be placed at the disposal of the War Department to be used in building a synthetic ammonia plant, employing the said process of the General Chemical Company, and of a capacity of 60,000 pounds of ammonia per twenty-four-hour day, said plant to be located in a region where land, water, coal and sulphuric acid are cheaply available, where good transportation facilities exist, and where the proposed new powder plant of the government can be properly located. In the opinion of this committee all of these conditions are best fulfilled by a location in southwest Virginia or contiguous region.

THE SCIENTIFIC MONTHLY

NOVEMBER, 1917

BACTERIOLOGY AND THE WAR¹

By Dr. DAVID JOHN DAVIS,

PROFESSOR OF PATHOLOGY AND BACTERIOLOGY OF THE UNIVERSITY OF ILLINOIS

THERE are so many aspects of this problem that it is somewhat difficult to determine where to begin and what to discuss. The war is so vast in its influence and bacteriology is so extensive in its scope that naturally they come into contact at many points. It shall not be my purpose, though it would be quite to the point, to discuss the great fields of agricultural bacteriology, industrial bacteriology, plant bacteriology and veterinary bacteriology. These all have a more or less intimate relationship with the war. I shall limit myself to that phase of the subject that concerns the prevention and cure of human affliction.

Nor shall I condescend to discuss the possible uses that deadly disease-producing germs may be put to in the willful destruction of human or animal life, highly suggestive reports of which have recently come to our attention. Even in war such practises are so repellent to every sense of honor and fair play that it is difficult to believe them in this twentieth century of Christian civilization.

The relation of bacteriology and war is a reciprocal one. While the study of bacteria has most fundamentally affected the success and the methods of procedure in military campaigns, in turn, there is presented to the bacteriologist for solution many new problems of vital interest to the science. Not only are new fields for investigation opened up by the war, but military organization furnishes opportunities for observation and confirmation of existing data on a scale and under conditions not usually possible in civil life.

During the war, the destruction of life by disease-producing germs often, indeed usually in the past, has far exceeded the

¹ Address delivered at the Opening Exercises of the University of Illinois, College of Medicine, Chicago, October 4, 1917.

destruction of life by bullets. We have only to point to the Spanish-American War less than twenty years ago to appreciate the truth of this statement. We may naturally anticipate therefore that in the present world war, the rôle that these minute creatures play will be one of first importance.

War, and especially the present war, involves the congregating and mingling of great bodies of men, frequently from distant parts of the world. This means the transportation of human and animal parasites along with the hosts. This transportation of parasitic varieties of animal or plant life we have long known to be a dangerous process. As examples, we may mention the Mexican cotton-boll weevil, the gipsy moth, and the foot and mouth virus. The bestowal by the white man upon the Indian of tuberculosis, syphilis, measles and smallpox along with culture and enlightenment has nearly cost the latter his existence as a race. In general, parasites transported to a new soil commonly increase their ravages enormously. This is one of the phenomena observed in connection with this war, examples of which will be cited presently.

The ravages of disease germs in the army may not be the most serious phase of this problem. The return of the troops to their homes—of the wounded during the war, and the entire army after the war—must lead to a more general infection of the civil population with the various diseases that commonly follow the military camps.

I shall now refer rather briefly to certain infectious, bacterial diseases which may serve to illustrate some of the more important advances for which the war, to some degree at least, is responsible. In general this progress naturally centers round studies dealing with the etiology and specific therapy of these infections.

Trench Fever.—An unusually interesting disease has made its appearance especially on the west front, to which the term trench fever has been given. This appeared shortly after the beginning of the war and was first definitely recognized and carefully described by Rankin in 1915. It has occurred especially in Flanders, France and England; also in Mesopotamia, the Balkans, Saloniki, among the Austrian and German troops on the eastern front and in the Tyrol.

Trench fever is not a good name, for it is known to occur in England and attacks often many persons who have never been to the trenches. It occurs virtually in epidemic form, thousands of persons at times rapidly coming down with the infection. It is different from any hitherto known disease. It is a definite clinical entity and is no doubt infectious in nature.

There is a typical fever curve, often relapsing in character, intense and constant shin pains, persisting often for months, and an increase in the mononuclear leucocytes, the total count usually being, in the febrile stage, 14,000 to 16,000. One attack does not confer immunity. It is never fatal, but causes often great suffering and distress and interferes seriously with the efficiency of the troops. No doubt our American troops in France will soon be infected, since it appears to be highly contagious.

The cause of the disease is entirely unknown, as is also its mode of transmission. Experiments on volunteers indicate that the disease can be reproduced by injecting blood from a patient into well persons and also that the virus resides in the blood corpuscles and not in the serum. Thus far no visible parasite has been detected in the blood. Trench fever has been less troublesome in the troops who have had good bathing facilities and who have in general been cleanest. Active campaigns against lice seem to have lessened the incidence of the disease. Captain Urquhard acquired the short form of the disease after permitting lice from a patient suffering with this disease to bite him. Lice are so common under present war conditions that practically every one is infested, and hence a history of pediculosis means little in determining transmission. At present it is not surely known whether or not lice are the usual or the natural agents in the transmission of this disease; they are, however, under strong suspicion.

One naturally asks whence comes such a disease. So far as we know it is an entirely new infection. Did it arise *de novo* as it were, by a sudden appearance of a mutant from some related virus? The discovery of its etiology may throw light on this problem, but as yet all attempts to find its cause have failed. Possibly this infection has existed unrecognized in some remote corner of the world and by the mobilization of various races in this world war it has found conditions suitable for its rapid spread.

Infectious organisms, no doubt, originate as do other species, but bacteriologists as yet have never observed an infectious disease arise. Is the disease of trench fever an instance of such a new infection? If this should be the case it might furnish a unique opportunity for the study of the ultimate origin of a disease. And after this trench warfare is over and the troops have scattered again to the corners of the earth, what will be the fate of this new disease? We shall watch this phenomenon with interest.

Infectious Jaundice.—Infectious jaundice appears to be a

common disease often occurring more or less in epidemic form. The cause of the jaundice seems to be varied. A certain proportion of the cases are no doubt intestinal in origin and caused by organisms of the paratyphoid group.

But another infection has been recognized which is now known to certainly cause a very considerable number of these icteric cases. It is commonly referred to as Weil's disease. This disease is not new, having been observed in previous wars; possibly it was responsible for many of the 70,000 cases of jaundice which occurred in our Civil War. It is characterized by intense muscular pains, high fever for several days, followed by jaundice and nephritic changes in the urine. Often intense hemorrhages under the skin and from the nose occur.

This disease is caused by a spirochete, the *Spirocheta icterohemorrhagiae*, which has now been repeatedly found in the various fluids and organs of the infected persons. It appears especially in large numbers in the kidneys and urine, as well as in the liver of the host. Most interesting are the observations recently made, particularly by Japanese investigators, that this germ commonly infects the wild rat, which may harbor it for a long time without special harm to itself. The kidneys of the rat likewise contain large numbers of the spirochetes and they are thrown out in the urine of the animal to infect the soil, and especially the water. Trenches would therefore furnish an excellent place for the dissemination of this disease. From the soil and water the organisms find their way into the human body both through the skin of the feet and into the intestinal canal. This disease has now been recognized along the entire western front. It is rarer in Belgium and France, but appears to be quite common along the Italian line. It prevails in the German armies and has attacked the British soldiers at Saloniki. In Japan the disease exists in a highly virulent form, especially among miners and rice planters who go barefoot. Work so far done along therapeutic and immunologic lines gives promise of success, but it is early as yet to make definite assertions on these points.

This disease is another example of an important human infection transmitted largely if not entirely by a lower animal and is also another severe indictment against that king of pests, the wild rat. Recently Noguchi has found this same spirochete in the kidneys of wild rats in New York city. Its dissemination probably has been quite general though not in large numbers. No doubt the war will tend to spread the disease still further and probably to cause a more universal infection of rats with the specific germ.

Trench Nephritis.—Trench nephritis is an exceedingly common disease on the various fronts, and, though much work has been done with the view of determining its cause, the real nature of the malady remains obscure. It manifests itself as an acute process and certain features of the disease suggest its possible infectious nature. Some of the cases at least may be infections with the spirochete of Weil's disease. Pathologically and clinically the disease closely resembles the form of nephritis seen following colds, scarlet fever, etc. No specific microbe has as yet been isolated and attempts to transmit the disease have failed.

Cerebrospinal Fever.—Cerebrospinal fever has long been known to be an army disease, though now it has come to be a serious menace in both peace and war times. It appears to affect soldiers living in camps, barracks, towns, etc., rather more than those engaged in an active campaign. During the present war it has occurred particularly in England, and early attacked especially the Canadian troops when quartered in that country. The disease during the past season broke out in several of our recruiting camps. As the summer advanced, the disease gradually subsided; excepting an occasional focus, there is little at the present time. However, unless radical measures are taken next winter and spring, we may predict to almost a certainty a recurrence of serious outbreaks of this highly dangerous malady.

Its cause, the meningococcus, finds its normal habitat in the nose and throat of human beings. Now and then it passes through the mucous membranes into the blood and lymph streams, finding its way into the region of the brain, especially the meninges, where it grows and produces an acute inflammation. By no means do all who harbor the germs in their nasopharynx develop the disease, but such "carriers" serve as dangerous reservoirs for the dissemination of the bacteria to others who may be susceptible. Naturally then the campaign against this infection consists in the proper treatment of "carriers," both healthy and sick, as well as in the curative treatment of those ill with the disease.

The war has furnished and is furnishing an excellent opportunity for a severe test on a large scale of methods of control and treatment which had been devised largely before the war. With reference to the serum treatment of the disease, perfected several years ago in the United States by Flexner, a large body of data tended to show the undoubted value of the intraspinal injection of serum as manufactured by the Rockefeller Institute. Some time before the war this institution

ceased making the serum, turning this work over to various public health and commercial laboratories.

In the winter of 1914-15 on the continent, especially in England, many cases of meningitis developed in both the civil and military population. Though the patients were promptly given the serum that was available, the death rate continued abnormally high, ranging 50 to 60 per cent. or even higher. The death rate in earlier epidemics in this country, when the Rockefeller serum was used, had been from 20 to 30 per cent. On investigation it was found that the trouble no doubt lay in the poor quality of the serum available at the beginning of the war. Since then the Rockefeller Institute has resumed its manufacture of the serum and other reliable laboratories here and abroad have also taken up the work with the result that during the past year the mortality of this disease in Europe and also in the United States Army compares with the earlier data, that is, 20 to 30 per cent. mortality. The serum should be made by the injection into horses of several strains of meningococcus, it being now definitely recognized that there exist a number of groups of these germs differing at least to some degree, especially in their immunologic properties.

As to the "carriers," especially those who are healthy or who show no definite symptoms of meningitis, considerable progress has been made in their management. The healthy "carrier" is more dangerous than the person ill with the disease. They outnumber the latter 10 to 30, or more, to one. Any individual coming into intimate contact with a meningitis patient is practically sure to become a "carrier." A nurse or a mother tending her sick child is certain sooner or later to contain the meningococcus in her naso-pharynx. The recognition of such persons is made possible by wholesale culturing on suitable media of entire bodies of troops and others coming in contact with them, and those harboring the germs are isolated and treated. The treatment is various. The germs may disappear in time without any special therapy. Often they are very persistent and resist most vigorous treatment. Tonsilectomy has been resorted to with little success. Encouraging results have been obtained by the vigorous use of nasal and throat sprays. For this purpose various antiseptics have been tried, but those most efficient seem to be 2 per cent. chloramin-T and zinc sulphate, 1.2 per cent. in watery solution.

It is to be emphasized that there is a real and serious danger from this highly fatal disease in the mobilization of troops from various parts of the country. However, we now know enough to quite successfully cope with it, provided we apply

what we know. The successful preventive measures include a careful survey of localities from which the men come with reference to meningitis, a systematic search for "carriers" and their retention until free from meningococcus; early diagnosis and isolation with repeated intraspinal injections of a reliable serum. To keep the disease out of a camp, every soldier should be examined for meningococci before he is allowed to enter the barracks.

Typhoid Fever.—Were one discussing this subject of infectious disease in almost any other war in history, the larger part of the time would be devoted to intestinal infections, especially typhoid fever. In this war, thanks largely to protective vaccination, the so-called enteric fevers have ceased to be a serious problem. Our knowledge of the dissemination of typhoid through carriers and of the methods for their detection is also a most important phase of the control of this disease.

The development of the use of vaccines in this disease during the last fifteen years must be counted as one of the great medical achievements of the age, and ranks beside Jenner's discovery of smallpox vaccination. This procedure used in the United States Army and elsewhere before the war and now submitted to the crucial test of protecting the huge armies in this war under most varied and critical circumstances has now, it would seem, demonstrated its value in a way which should convince the most skeptical. What further proof is necessary to show that now typhoid fever or at least a large part of it in our country and elsewhere is entirely unnecessary. The problem has been solved from the standpoint of scientific medicine. It is now a public health and social problem. In other words it is squarely "up to the people" as to whether or not they wish to use what the contributions of medical science have given them.

Paratyphoid fever, a disease simulating typhoid, but less fatal, has been a serious infection in certain regions. This was largely because proper vaccination was not resorted to, for example, in the Gallipoli campaign. The experience of the war, however, has confirmed the results, obtained on a limited scale before the war, that vaccination with paratyphoid bacilli is as efficacious in preventing this disease as is the procedure in typhoid fever. Often vaccines are administered composed of mixtures of typhoid bacilli and paratyphoid, A and B, and in the eastern front, the cholera bacillus is also added. The injection of mixtures of these varieties of dead bacteria has been found to immunize satisfactorily and saves much time.

Asiatic Cholera.—Asiatic cholera naturally has, in the east

where it is more or less endemic, been responsible for many cases of sickness, but great epidemics have not developed. The problem here is almost identical with that of typhoid and paratyphoid fevers. Vaccination with dead or treated cholera vibrios, the detection of "carriers," and proper control of water and food supplies are the procedures which will make Asiatic cholera as little feared by the soldiers as is smallpox.

The *Dysenteries* are in a less satisfactory state than the typhoid fevers. Especially in the eastern and Mediterranean campaigns both amebic and bacillary types of the disease have been very prevalent. No serious outbreaks have occurred on the western front. Extensive and valuable studies, especially of the protozoal varieties, have been made by the Medical Research Committee of Britain and our knowledge of them has been greatly extended. Vaccination has not proved of great value in this disease, probably because of the high toxicity of the bodies of the bacilli. The problem of "carriers" is here paramount and through proper hygienic precautions satisfactory progress is being made in the control of this disease. In amebic dysentery we have a very effective therapeutic agent, emetine, the favorable results obtained heretofore having been abundantly confirmed on an extensive scale in the military camps of the Mediterranean countries. Emetine given subcutaneously, while practically curing the disease, does not sterilize the intestinal canal and such individuals often become chronic "carriers" of amebæ. Dale and others have used a new compound, emetine bismuth iodide, by the mouth and have found it more effective in completely sterilizing the patient of his amebæ. Oral administration is therefore likely to supplant the hypodermic use of emetine in this infection.

Wound Infections.—Wound infections of all kinds have of course appeared in this war on a scale never before met with in the history of medicine. With these the bacteriologist and the surgeon have contended valiantly and on the whole hopeful progress has been achieved. The nature of the warfare makes primary disinfection of the wounds usually impossible and often suppuration is well advanced before the patient reaches the surgeon. The pyogenic cocci, fecal bacteria and especially the anaerobes are the chief offending organisms.

In the management of these cases, the medical men have, as it were, arranged themselves into two schools. First, those who rely chiefly upon the physiological mechanisms in the body to combat and resist the invading germs and, second, those who depend on the application from without of antiseptic substances to kill or prevent development of germ life.

Sir A. E. Wright, known to the world for his studies in pathology, especially in phagocytosis, has well been called "the apostle of physiological methods." Wright, during this war and close to the front, has done splendid work in the field of surgical bacteriology. He has devised methods for drawing into the infected areas the fluids of the body containing the protective substances normally found there. For this purpose he has used strong solutions of salt, often indeed packing the wound with solid salt for a time, in order to stimulate the free flow of lymph to the area. He has also devoted much time to the continuous irrigation of wounds with hypertonic salt solutions and good results have been reported from this method.

Hopeful progress may also be reported in the field of antiseptic surgery. The ideal antiseptic of course is one which will kill the microbes and not injure the body tissues. The older methods of the application of powerful germicides, destructive of tissues as well as germs, have been largely superseded by the application of more specific substances. This work has centered largely around chlorine compounds. The work of Dr. Dakin and Dr. Carrel, the well-known investigators from the Rockefeller Institute, has resulted in the use of a special technique for the continuous irrigation of wounds with a modified hypochlorous solution. This treatment, according to many surgeons, has led to marvelous results, reducing the bacterial content of wounds to the point where often early closure is possible. This method has become very popular with surgeons, especially at the front, and is, according to many, the best method yet devised in dealing with suppurating wounds.

Dr. Dakin has extended his work by showing that the chlorine from the hypochlorites combines with proteins in such a way as to form substances known as chloramines. These bodies, though possessing a high germicidal value, seem to be quite non-toxic and have no action on albumen. A certain preparation known as chloramin-T has come into very general use, especially in mouth infections, in saturating gauze for antiseptic purposes and as a most efficient throat spray in the treatment of meningococcus carriers.

Another antiseptic that deserves mention is a benzol derivative known as flavine. This was originally prepared in Ehrlich's laboratory some years ago for the treatment of trypanosomiasis. Recently the bactericidal power of this substance has been carefully studied in England by several investigators who find that it is an active and efficient antiseptic without possessing harmful effect on phagocytosis or on tissues

generally. Furthermore, its antiseptic action is actually enhanced in the presence of serum rather than diminished, as is the case with practically all other antiseptics known. It is quite non-irritant and can be used in continuous irrigation after the method of Carrel or in conjunction with the salt pack method of Wright. Brilliant green, another benzol derivative, has been found to possess similar properties and is even more highly germicidal, though it acts less efficiently in serum. Sufficient time has not elapsed nor have these substances been available in sufficient quantities for the thorough and crucial tests necessary to establish them on an absolutely permanent basis as surgical antiseptics. The report of the Medical Research Committee of the British Government on these substances, however, is highly favorable. It is to be noted that these substances are of such a nature that it is possible to combine the methods of the two schools mentioned above, the physiological and the antiseptic, and thus bring the advantages of both into play against microbic invasion of the tissues.

Tetanus.—Lockjaw or tetanus is an anaerobic infection primarily of wounds long feared by the military surgeon. In the early part of the war, especially during the battle of the Marne, when inadequate medical supplies prevented the use of serum, many cases of lockjaw developed. Later, protective inoculation of tetanus antitoxin was administered promptly to every wounded soldier as soon as possible after leaving the firing line and the results have been most gratifying. In the British Army in October of 1914 the ratio of cases of tetanus to wounded men was 32 per 1,000. In November of that year following the introduction of universal immunization of the wounded the ratio fell to 2 per 1,000, at which point and even lower it has continued to the present. Not only has the number of cases been very greatly reduced, but the serum has markedly modified the course of the infections that do occur.

Local tetanus as opposed to generalized disease is recognized as a phenomenon of partial protection. Cases of delayed, late and post-operative tetanus have been carefully studied. Tetanus spores apparently may lie in the tissues for long periods little affected by the antitoxin and later through an operation or trauma may resume their development. Therefore repeated prophylactic inoculations under certain conditions seem essential, especially before surgical procedures. The danger of anaphylaxis is practically negligible.

Curative treatment of the disease by the antitoxin can not be regarded as satisfactory. The intra-spinal injection of the serum is practised, and there is some evidence to indicate its

efficacy, especially when given early. But its curative value does not compare with its protective value.

This data—and the above statements are based on an enormous number of cases—is not new. In general it agrees entirely with what we knew before the war of the value of anti-tetanic serum. But the war has furnished an opportunity for testing the serum on a scale never before possible and the results have convinced many who previously were skeptical of its value. Before leaving the subject I can not refrain from directing your attention to the enormous number of soldiers saved by this one simple procedure—a procedure, I may say, based upon and made possible by the application of scientific bacteriologic principles.

Gas Gangrene.—Another wound infection caused by an anaerobic bacillus, and quite commonly observed in deep wounds of the muscles, is gas gangrene. The infecting agent is a spore-bearing bacillus, the *Bacillus Welchii*, a common inhabitant of the intestinal canal, clothing and particularly of contaminated soil. Soldiers engaged in trench warfare, and especially those receiving deep lacerating wounds with shrapnel, in which dirt and soiled clothing are carried into the flesh, mostly suffer with this type of infection. The bacillus grows particularly well in muscle tissue, producing an inflammable gas which penetrates tissues where it can easily be detected by the characteristic crepitus.

This infection complicating wounds is extremely serious and nearly always results fatally. The organism appears to produce a highly toxic substance, the real nature of which has not yet been determined with certainty. The prevalence and the seriousness of this infection to the surgeon has stimulated considerable work on the nature of the toxins secreted. Of first importance is the recent work of Bull and Pritchett² of the Rockefeller Institute, who believe they have discovered a soluble toxin produced by the bacillus when grown in media containing a small amount of sugar. By injecting the toxin into animals, they claim they have produced an antitoxin which is effective in neutralizing the poison, and animal experiments indicate a definite protective action of the antitoxic serum against the toxin.

Reports of the action of the antitoxin in human cases are not as yet available. Naturally work of this kind needs confirmation before it can be accepted. Repetition of Bull's experiments are going on in various laboratories and we shall

² THE SCIENTIFIC MONTHLY, October, 1916, p. 310.

soon know the results. The importance of this work, if confirmed, will compare with that of the discovery of tetanus antitoxin.

Typhus Fever.—The brilliant work of American investigators, especially Ricketts on typhus fever in Mexico a few years before the war, was done at an opportune time. It was then shown clearly that typhus fever is transmitted by the body louse and in all probability only in this way. This fact at once determined the method of attack, and it was soon shown that the disease could be absolutely controlled by the extermination of this parasite. Consequently, when typhus fever early in the war broke out on the eastern front, especially in Serbia, medical science was at hand with the proper knowledge of how to control this plague. The excellent work of the American Commission under Dr. Strong in Serbia, aided by well-organized British units, is well known to the world. By the elimination of lice, it was possible in a relatively short time to bring the epidemic under complete control.

The etiological agent of this disease has not with certainty been determined. Plotz and his associates in New York believe the agent to be a bacillus which they have isolated from the blood and organs of patients suffering with the disease. They report specific immune reactions with this organism and certain suggestive animal experiments. However, entirely different organisms have been described as etiological agents by other workers. Further work must decide what the true causal organism may be.

This disease has not appeared on the western front and is not likely to. Our American troops are therefore in no danger from this infection. The disease is now known to occur in a mild form in this country, particularly in New York City and in all probability cases have even been observed recently here in Chicago.

Other diseases of a bacterial nature might be briefly referred to, chiefly because of the necessity to cope with them in connection with the military organization of countries. The tubercle bacillus is in many countries, but especially in Belgium and France, decidedly increasing its ravages over peace times. This is due to a number of causes, but chiefly to the poor and inadequate food supply and to exposure. The venereal problem, as usual in wartime, presents itself in formidable proportions. Almost drastic measures have been instituted by the countries in their efforts to cope with these diseases. Germany has enacted stringent laws applicable to soldiers and especially to those who are now discharged and to those discharged at the

end of the war. The radical laws already in effect in Australia with the view to regulate the venereal peril will be watched with interest by all students of hygiene and preventive medicine.

Pneumonia and rheumatic fever in the armies in Europe, strange as it may seem, have not, according to all reports, appreciably increased their incidence over that met with in the civil population. Poliomyelitis has not as yet menaced the military camps.

The above-mentioned diseases discussed in this rather brief way furnish some idea of the more important specific advances that have been going on during the war in the field of bacteriology. In general, it may be said that these advances cover fairly well the entire field of this science so far as it is related to pathogenic bacteria.

Influences of a less specific character are resulting from the war, especially along the lines of general medical research and also in the education of the people in hygienic matters.

The admixture of medical men from various countries brought on by the war, all of whom are necessarily interested in bacteriological problems, has resulted and will result in a most desirable and profitable exchange of ideas, from which we may reasonably expect further valuable contributions to the science.

The education of not only medical men but of the common soldier in military hygiene will in itself be a great stimulus to the science of bacteriology, since military hygiene is so largely based on bacteriologic principles. The instruction now given to the soldiers by lectures and in other ways will make them more intelligent about such matters in general and no doubt will result in an increased interest in this subject by the common people.

The value derived from the physical examination, the military training, the careful supervision exercised in the army over the general health and hygienic environment of the soldier will be of first importance in raising the resistance of the men to the invasion of bacteria of various kinds. The proper control of liquor in itself will accomplish much in reducing the incidence of several bacterial diseases now dependent largely upon the abuse of alcohol.

A most important problem from the standpoint of infections is the proper care of the teeth. Never before has so much attention been given to the hygiene of the mouths of the soldiers and to instruction of the men on this subject. This should eliminate many serious infections about the mouth, jaws and

face, and it will no doubt educate the entire people along a line heretofore sadly neglected. This interest in dental bacteriology in the army is largely due, no doubt, to the progress made in recent years especially in the United States and England in the study of focal infections about the mouth and teeth and the dissemination of such infections to other regions of the body.

I consider it entirely proper here to call attention to the very important rôle that American bacteriology and hygiene has played in this great war. Not only the work done since the beginning of the war but that done before the war has had a most significant application to the great medical problems at hand. The work of Flexner and his associates of Rockefeller Institute on meningitis, the investigations of Reed, Carroll, Lazear and Agramonte, on the control of yellow fever in Cuba, the work of Gorgas in making a health resort of the disease-infested Panama Zone, the work of Carrel, Dakin and a number of other brilliant American surgeons on wound infections and their treatment, the researches of Flexner, Noguchi, Mathers, Rosenow and others on poliomyelitis, the work of Ricketts, Wilder, Anderson, Goldberger and other Americans on the etiology and transmission of typhus and the remarkably prompt and efficient control of the Servian epidemic of typhus by Dr. Strong and associates, the promising studies of Bull and Pritchett on gas gangrene, all these constitute a series of contributions which, from a military point of view, are fundamental in the conduct of a great war. Already we may say American medical science has carried on its side of the military campaign and has set a mark for preparedness which might well excite the admiration of, and indeed furnish a lesson to, the other departments of our military organization.

And finally let me say that while no doubt in a relatively short time this great war among nations will cease, the great war against the countless hordes of disease-producing germs will go on for ages yet to come. This war of man against disease is in every sense a real contest, in which there are pitted against each other mechanisms far more intricate and complicated than have yet been devised by man in the European War. While the contest between man and man may be more spectacular and may involve greater destruction in mass, the assault by the microbes is far more insidious, more elusive, and on the whole far more deadly. Indeed war is in a sense simply an incident which man foolishly permits to enter into that greater struggle with germ life and which often gives the upper hand to the latter. The great armies of men, women and children that are destroyed every year by bacterial diseases make

the destruction of life in Europe seem almost trivial. We speak of this war resulting in the loss and maiming of twenty million lives. Bubonic plague, the black death, five centuries ago in one epidemic in Europe killed twenty-five million persons. One might point to the army of 150,000 in the United States alone carried off each year by the tubercle bacillus, another 150,000 destroyed by the pneumococcus, 25,000 by the typhoid bacillus, several thousand more by smallpox virus and so on. What a pity some of the energy, time and money spent in the great war could not be spent in combating the deadly microbe. A combined attack against several of our great diseases, such as the nations are making against each other, would no doubt result in their extinction. Yellow fever is limited to certain well-defined areas and an allied attack on the several endemic foci would probably exterminate it. Bubonic plague, when not on an epidemic rampage, is localized in three or four well-defined regions of the world. A concerted attack by various nations, using all the modern weapons of microbic warfare, would almost certainly annihilate that triple alliance between the plague bacillus, the rat and the flea, upon which the disease depends for its existence. Asiatic cholera would probably be vulnerable to a well-directed assault. For the existence of several well-known germ diseases, like smallpox and hydrophobia, there is no excuse excepting the stupidity and ignorance of the people. It has been said that we are twenty-five years behind the times so far as the actual application of scientific and laboratory medicine to the control of infections is concerned. In general this is true. For certain diseases like smallpox we are far more than twenty-five years behind the times. We know enough about several of our diseases and have for years known enough to render them extinct. But we do not yet know how to execute this knowledge and to make it bear fruit as it should. This is not primarily a bacteriological or medical problem, but a social one. Indeed it is one of the great problems of democracy.

THE SUN AND THE WEATHER¹

By DR. C. G. ABBOT

SMITHSONIAN INSTITUTION

“CHANGEABLE as the weather,” we say, when the roaring gale follows hard on the heels of a cloudless day. But from another point of view the wonder is that weather changes disastrous to life occur so seldom. Experiments indicate that the higher forms of plants can not grow where temperatures remain continuously below 0° or above 50° C. (32° and 122° F.). These are extremes, and most food plants can only thrive within much narrower ranges. Wheat and maize are grown within the belt whose mean yearly temperature lies between 4° and 20° C., oats and barley — 2° to 20° C., rice 20° to 30° C., and potatoes 2° to 16° C.

Despite these limiting conditions, no migrations of men seem to have been forced by climatic changes within historical times, extending over 5,000 years, and there is no evidence to show that the habitats of food plants have altered their latitudes during this interval. Geological evidence, however, indicates that such changes and accompanying forced migrations have occurred in past ages, but probably not of great magnitude within intervals of 5,000 years.

To bring out more strongly this remarkable constancy, in a recent paper Sir F. Stupart says:

One of the arguments in favor of stability of climate, first used by the Danish botanist and meteorologist Schouw, is as follows: In order that dates shall come to maturity the mean annual temperature must be at least 69° F. (20.6° C.). On the other hand, the vine can not be profitably cultivated when the mean annual temperature exceeds 72° F. (22.2° C.). . . . The palm and vine grew together in Palestine in the days of early biblical history, and they both grow in the same district to-day. . . . That the rainfall of Palestine has not changed in 2,000 years receives confirmation from some measures of rainfall recorded in the Mishnah. . . .

The temperature of the earth depends almost wholly on the balance of two energies. First is the incoming energy of the sun's rays, both visible and invisible, second is the outgoing energy of the earth's rays. These latter are wholly invisible to the eye, and can only be detected by thermometric appliances.

¹ Published by permission of the Secretary of the Smithsonian Institution.

The fundamental nature of earth rays, however, in no way differs from that of light. The only difference resides in their wave-lengths. Light-waves range from 0.0004 to 0.0008 millimeter, earth-ray waves from 0.004 to 0.050 millimeter. The hotter the earth's surface becomes, the more copiously it emits these long-wave rays, so that at a certain temperature of the earth its output of energy to space equals its income, which is almost wholly from the sun. Solar rays lie chiefly between 0.0003 and 0.003 millimeter in wave-length, although extending feebly to very long-wave regions.

Neither sun-rays nor earth-rays pass freely through the atmosphere. Clouds, dust, water-vapor, carbon-dioxide, oxygen, and even the molecules of the air—all hinder the passage of the solar rays. Approximately 40 per cent. are reflected away to space without tending in the least to sustain the terrestrial temperature. Of the remaining 60 per cent. about one fifth, or 12 per cent., is absorbed in the atmospheric water-vapor, so that its heat is distributed through the atmosphere from a level of five miles or more down to sea-level; and about two fifths, or 24 per cent., are absorbed in clouds, principally between levels of one and two miles. Thus it seems that little more than 20 per cent. of the sun-rays intercepted by the earth as a planet are absorbed directly to produce heat on its solid and liquid surface.

An even greater atmospheric obstruction occurs to terrestrial rays. Of the output from the earth's surface, about half is absorbed in clouds, and three fourths of the remainder in water-vapor and carbonic-acid gas of the atmosphere, so that hardly more than 10 per cent. of the radiation of the earth's solid and liquid surface escapes directly to space. By successive radiations from place to place within the atmosphere, the energy does at length reach high levels where it is more free to escape from the earth. Yet the atmosphere plays strongly the part of the blanket upon the couch, or the asbestos covering upon the steam pipe, or still more accurately the glass cover over the hot-bed. In consequence of this blanketing effect of the atmosphere the mean surface temperature of the earth is probably 30° C. (54° F.) warmer than it would be if terrestrial rays passed freely from the earth's surface to space. Not only so, but the change of temperature between night and day is very greatly reduced by the same agency.

Experiments of Lord Rosse, Langley and others showed that in the brief period of a few hours during a lunar eclipse the moon's surface falls from a temperature well above freezing,

even perhaps approaching that of boiling water, to a temperature far below freezing. As the moon is situated similarly to the earth as regards solar distance, but lacks an atmosphere, we readily see from this observation the great value of our atmosphere to equalize temperature. On the earth the maximum range caused by night and day, even in deserts, rarely exceeds 20° C. At most stations the mean daily range is less than 10° C.

Dependent as we are on food crops, which in turn depend on restrictions of temperature range, it seems safe to conclude that human life would be impossible here if it were not for the tempering action of clouds, water-vapor and carbon dioxide, in restraining so strongly the escape of radiation from the earth's surface. These constituents of the atmosphere make hardly 3 per cent. of its weight, but they are the all-important agents for this purpose. Oxygen and nitrogen play little part in restraining terrestrial radiation, though they scatter the incoming shorter wave-length solar rays powerfully, and thus produce the brightness and blue color of the sky.

Many years ago Professor Hann, of Vienna, published an investigation of the variability of mean daily air temperatures from day to day. Ninety stations well distributed over the earth were considered. It may be said, speaking roughly, that the region of United States and Canada from the Great Lakes to the Coast Range, and from the Ohio River to Hudson Bay is twice as variable in climate as any other large area of the inhabited world outside of Asiatic Russia. But as shown in the accompanying table, when we consider the changes on a percentage basis, measuring our departures from the absolute zero where temperature begins, we get an impression of extraordinary stability rather than of changeableness. So great a degree of stability compared with the variableness of other quantities such as length of life, stature, weight and wealth of individuals is indeed almost unexplainable, in view of the variable elements we have been considering, on which temperatures depend. Despite variable screening substances which cut off 80 per cent. of incoming heat and 90 per cent. of outgoing heat, mean daily surface air temperatures in most parts of the world rarely vary 1 per cent. from day to day.

As we have seen, the complete cutting off of solar radiation at night by no means causes the earth's surface temperature to fall to the absolute zero. This is because the darkness does not last long enough to permit the escape of more than a small fraction of the available heat of the earth. We have mentioned the

powerfully hindering atmospheric constituents which cut down the rate of loss of terrestrial heat, and now we may note conditions which govern the quantity of heat available to escape.

AVERAGE NUMBER OF DAYS PER YEAR IN WINTER, SPRING, SUMMER AND AUTUMN WHEN OCCUR VARIATIONS OF MEAN DAILY TEMPERATURE BETWEEN CERTAIN LIMITS EXPRESSED IN DEGREES C. AND ALSO IN PERCENTAGES OF ABSOLUTE TEMPERATURE (WHERE FREEZING IS 273° ABS. C.).

Station	Limits		Number of Days in			
	Degrees C.	Percentage	Winter	Spring	Summer	Autumn
Leavenworth, Kansas.....	0.0 to 1.5	0.0 to 0.5	21	24	29	26
	1.5 to 3.0	0.5 to 1.0	17	20	24	21
	3.0 to 7.5	1.0 to 2.5	29	32	25	30
	7.5 to 15.0	2.5 to 5.0	20	15	4	13
	over 15.0	over 5.0	3	1	0	1
Paris, France.....	0.0 to 1.5	0.0 to 0.5	42	46	45	46
	1.5 to 3.0	0.5 to 1.0	28	28	28	28
	3.0 to 7.5	1.0 to 2.5	19	17	18	16
	over 7.5	over 2.5	1	1	1	1
Sydney, Australia.....	0.0 to 1.5	0.0 to 0.5	50	45	47	58
	1.5 to 3.0	0.5 to 1.0	25	24	24	23
	3.0 to 7.5	1.0 to 2.5	15	19	19	10
	over 7.5	over 2.5	0	3	2	0

Available terrestrial heat varies greatly with the locality. On the water the surface layers, if above 4° C. (39.2° F.) in temperature, contract by cooling, and becoming more dense sink down and are replaced by warmer water from below. Hence a great depth of water, at least 10 meters (33 feet), is available to give up heat. Moreover, the capacity for heat of water is very high, so that a given weight of water gives up about five times as much heat as the same weight of rock cooled through equal temperature difference. Furthermore, the cloudiness and humidity of the atmosphere is generally greater over the oceans than over the land. For all these reasons the daily and yearly changes of temperature are relatively very small over the oceans.

On land, especially desert land, the available heat is much less. No exchange of warm for cooled material being possible, heat can only flow from beneath the surface by conduction. Soil and rock are such very poor conductors that no appreciable change of temperature takes place between night and day on land below a depth of 50 centimeters (20 inches). On account of this, the heat available to escape during the night over a land surface resides almost as much in the atmosphere as in the earth, unless the soil is very wet, so that oceanic conditions are to some extent duplicated. We see, therefore, the explanation of

the great difference between oceanic and continental climates. The former have much the smaller changes of temperature from day to night and from summer to winter. Compare, for instance, the mean hourly and monthly temperatures of Timbuctu and Port au Prince, stations of nearly equal latitude.

MEAN HOURLY DEPARTURES FROM MEAN TEMPERATURES C.

Hours	Midnight	2	4	6	8	10	12
Timbuctu.....	-4.1 ⁰	-5.6 ⁰	-6.8 ⁰	-7.7 ⁰	-2.8 ⁰	+3.2 ⁰	+6.9 ⁰
Port au Prince.....	-2.6	-3.2	-3.7	-3.8	-0.6	+2.9	+4.7

Hours	2	4	6	8	10	Mean	Range
Timbuctu.....	+8.5 ⁰	+7.4 ⁰	+3.4 ⁰	-0.1 ⁰	-2.4 ⁰	29.2	16.2
Port au Prince.....	+4.5	+3.1	+1.1	-0.8	-1.3	25.9	8.5

MONTHLY MEAN TEMPERATURES C.

Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Range
Timbuctu.....	21.8	23.8	28.1	32.5	35.0	34.2	32.7	31.1	31.8	31.0	26.8	21.4	13.6
Port au Prince.....	24.1	24.6	25.1	25.9	26.0	27.1	27.6	27.3	26.7	26.3	25.6	24.4	3.5

Thus Timbuctu in the Sahara Desert has twice the daily range and four times the yearly range of temperature that Port au Prince on the coast of Haiti does.

Besides the atmospheric blanket and the heat capacity of the surroundings, a time element affects the range of temperature changes attending fluctuations of solar radiation. A rotating disk having a sector of its surface cut away is often used to diminish the apparent intensity of a beam of light. If the disk is rapidly turned, the eye can not detect the changes from light to darkness, and *vice versa*. The effect seen is that of a light of diminished brightness. But if the speed is reduced, fluctuations become more and more noticeable, till at slow speed the full change from light to darkness is apparent. Similarly it should be with changes of the earth's temperature produced by changes of solar radiation. If the solar changes were sufficiently slow, they should produce complete and equal temperature changes at all stations, whether desert or oceanic, provided no secondary changes of cloudiness or humidity, or other variable elements, accompanied.

How large a terrestrial temperature change ought then to follow a slow increase of 1 per cent. in solar radiation?

Evidently the earth's temperature should increase until its

own radiation to space becomes 1 per cent. greater. Bodies which emit radiation by virtue of their temperature are of more or less radiative efficiency, but all natural bodies fall short of the theoretical "perfect radiator." This instrument is closely approached by an enclosure with a minute opening for the escape of its radiation, and with walls of equal temperature. For the "perfect radiator" the emission is proportional to the fourth power of its temperature above absolute zero. It is known that water is very nearly a perfect radiator at ordinary temperatures, and moist soil also. Hence we shall not be far wrong in supposing that the radiation of the earth varies as the fourth power of its absolute temperature. Thus in order to increase its radiation 1 per cent. we should expect an increase of the earth's mean temperature from 287° Abs. C. to 287.7° Abs. C.; for the fourth powers of these numbers differ by 1 per cent. For very slow fluctuations of solar radiation of a few per cent. range we therefore expect 0.7 as many degrees change of terrestrial temperature as the number of per cent. change of solar radiation.

Compare this with the yearly range at Timbuctu. Taking into account the obliquity of the rays and the distance of the sun, the yearly range of solar radiation at north latitude $16^{\circ} 49'$ is 34 per cent. Corresponding to this we expect 24° temperature change. The actual change is 13.6° at Timbuctu. From these figures we conclude that, even for desert climates, changes of solar radiation must be of several years period to produce their maximum temperature effects. It seems probable that solar radiation changes attending the eleven-year cycle of sunspots may be sufficiently slow to produce nearly full temperature effects, not only in deserts but over the world in general.

What changes of solar radiation attend the sunspot cycle? Owing to effects of clouds, haze, humidity and dust in the atmosphere, it is not possible to determine changes in the solar emission of radiation, without using complicated apparatus and methods of observing, and conducting the research at more than ordinarily favorable stations. In short, no observations competent to determine real solar radiation changes were made prior to the year 1905. Since then suitable measurements have been conducted for several months of each year (excepting 1907) by the Smithsonian Astrophysical Observatory, at a station on Mount Wilson, near Pasadena, California. The results obtained give values of the so-called "solar constant of radiation." This is the quantity of energy per square centimeter per

minute received at right angles to the solar beam in free space at the earth's mean solar distance. The following table shows the yearly mean values, usually representing about 100 days each, as obtained at Mount Wilson in the months June to October, inclusive.

SUNSPOTS AND SOLAR RADIATION

Year	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915
Solar constant...	1.956	1.942	—	1.936	1.918	1.921	1.923	1.940	1.907	1.948	1.949
Spot number....	62.5	53.8	62.0	48.5	43.9	18.6	5.7	3.6	1.4	9.7	46.0

These figures do not indicate a very close dependence between the prevalence of sunspots and the intensity of the sun's emission of radiation, yet they do seem to indicate that there is a tendency to increased radiation when the sunspottedness is rapidly increasing, or at maximum, compared with the period when the sunspottedness is rapidly declining or at minimum. Contrasting from this point of view the mean values for the years 1905-6-8 and 1914-15 with those for 1909-10-11-12-13, we have:

	5 Active Years	5 Inactive Years
Mean solar constant	1.946	1.922
Mean sunspot number	46.1	14.6

If this be regarded as typical, we learn that an increase of 25 sunspot numbers is attended by 1 per cent. increase of solar radiation. The average range of sunspot numbers in the 15 sunspot cycles from the year 1750 to the year 1906 was 90, so that on the basis just stated an average sunspot maximum might be expected to be attended with 3.6 per cent. more emission of solar radiation than the minimum of sunspot activity. This, according to our preceding conclusion, might be expected to be attended with a general *increase* of terrestrial temperature of 2.5° C.

The dependence of sunspots and terrestrial temperature has lately been investigated by the method of correlation (of which we shall say more below) by Dr. Walker, director general of the Indian Meteorological Department. His studies deal with 97 stations in all parts of the world and show that with the exception of northwestern Africa, the west and north coasts of the Eurasian continent, Bermuda, New Zealand and a part of the Indian Ocean, the world in general has *lower* temperature at sunspot maximum than at minimum. Numerical values have been obtained for a great number of stations, and for long periods of years, by several investigators, but notably by

Köppen. He finds that for the interval from 1815 to 1873 the average *decrease* of terrestrial temperature at sunspot maximum was 0.7° C., and for the interval 1873 to 1910, 0.5° C. The difference may well be attributed to the greater average intensity of the sunspot maxima in the former interval.

Here then is a well-established paradox. Increased solar activity, as indicated by sunspots, is attended by decreased terrestrial temperature. It has been suggested, but not demonstrated, that the explanation lies in an increase of cloudiness at sunspot maximum; and that the increase of cloudiness is caused by the penetration of the atmosphere to lower levels by electric ions shot from the sun with greater power at maximum solar activity.

Besides these variations of solar radiation from one year to another, the Smithsonian observations indicate fluctuations which run irregular courses, often in a week or ten days. The true solar existence of these changes has been confirmed in several ways, among others in the years 1911 and 1912 by making the measurements simultaneously in California and Algeria, separated by a third part of the earth's circumference. More recently it has been found that the changes are accompanied by variations of brightness over the sun's disk. Dr. Bauer, too, has shown that fluctuations of the earth's magnetic field accompany them.

As an example of these changes, see the following observations of September in the year 1911.

Date September	3	4	5	6	7	8	9	10	11
Solar constant value	1.888	1.906	1.917	1.960	1.938	1.993	1.948	1.908	1.892

The observed range here is $5\frac{1}{2}$ per cent. in eight days. What effect should this produce on the weather?

Recalling that a change of 100 per cent. in twenty-four hours produces a temperature change of 8.5° C. at Port au Prince, and 16.2° C. at Timbuctu, while 34 per cent. change in 365 days produces 3.5° C. at the former and 13.6° C. at the latter of these two stations, we should expect that for the average station a solar radiation change ranging 5 per cent. in eight days might produce about 0.8° C., or nearly 1.5° F., temperature fluctuation. But as we have seen that for many stations the increase of solar radiation, which seems naturally to accompany the great solar activity of sunspot maximum, is attended by *lower* terrestrial temperatures, we may not be surprised if things turn out less simply than expected in regard to the short interval solar fluctuations.

The subject has lately been investigated by Dr. H. H. Clayton, of Argentina, formerly of Blue Hill, Mass. In such an investigation a natural procedure would be to make two superposed curves, one to show the change of solar radiation day after day, and the other the change of temperature. The trouble with this method is that there are so many influences that operate on the weather, apparently haphazard, that their combined effect often masks the influence under investigation. Accordingly, Dr. Clayton employed the mathematical method of correlation, which has come into general use in biological researches. In this method two functions, like the diameter and circumference of a circle, that are related so intimately that the increase of the one depends only on the increase of the other, are said to have a correlation coefficient $+1$. Two functions, like the heights of two ends of a balance, which are so connected that increase of one depends only on decrease of the other, are said to have a correlation coefficient -1 . Between these perfect degrees of positive and negative correlation lie all degrees of dependence, and a coefficient of correlation, zero, indicates that the variables are unrelated. As in other investigations, it is valuable to determine the probable error of each coefficient of correlation, and one considers a correlation standing alone as demonstrated when its coefficient is numerically three or four times its probable error. A group of correlations may, however, so obviously support each other as to lend certainty to the correlation of individuals of the combination, though these individual members would otherwise be doubtful in view of probable error.

Dr. Clayton determined for about fifty stations, well distributed over the globe, correlation coefficients connecting temperatures with solar-constant values determined at Mount Wilson in 1913 and 1914. As he thought it likely that the terrestrial influence of solar changes would be deferred, he computed the correlations not only for identical days, but for the 1st, 2d, 3d, 4th, and 5th days thereafter. Here are examples of the largest correlation coefficients obtained.

Days Following Solar Observations.....			0	1	2	3	4	5
Station	Latitude	Longitude	Correlation Coefficient					
Pilar.....	31° 39' S.	63° 5' W.	0.32	0.51	0.54	0.48	0.33	0.13
San Diego.....	32° 43' N.	117° 10' W.	0.18	-0.10	-0.29	-0.50	-0.52	-0.44

Probable error about ± 0.07 .

From this we see that at Pilar, Argentina, *increase* of temperature followed increase of solar radiation, and the maximum effect occurred after one or two days, while at San Diego, California, *decrease* of temperature followed increase of solar radiation, and the maximum effect occurred after three or four days. The coefficients of correlation at maximum are fully seven times the probable error numerically, so that the connection is well assured. For other stations different values, some positive, others negative, were obtained, ranging down to zero.

When marked on the map the stations of positive and negative correlations were found to arrange themselves very definitely in zones. Speaking roughly, in the zone within the tropics, but broadening over land areas and narrowing over the oceans, the correlation is positive, and so also in the arctic and antarctic zones, and extending down the east coast of North America. In the remainder of the world, comprising the great temperate zones, the correlation is negative.

A similar investigation, but less extensive, was made by Clayton on the relation of atmospheric pressure to solar radiation. Similar zones seemed to be indicated, but where temperatures rose after increases of solar radiation, pressures fell, and *vice versa*.

For several of the stations, Clayton's investigation indicates the actual numerical changes in temperature which follow a change of solar radiation. From the average of all the decided changes of solar radiation, I find from his curves that for 1 per cent. solar change there was 5.2° C. average change in temperature at Pilar, 1.5° C. at Manila, and 6.3° C. negative change at Winnipeg. Other stations would appear to give equally surprisingly large results. Clayton's figures, however, relate to maximum daily temperatures. It may be reasonably supposed that the changes of mean temperature corresponding to 1 per cent. increase of solar radiation would be half as great, or $+2.6^{\circ}$, $+0.75^{\circ}$ and -3.15° C., respectively, at the three stations. We had been led to expect almost surely not more than 0.7° , and probably not more than 0.2° C.

Five thoughts are suggested by this remarkable result. First, that the figures ought to be confirmed by tests extending over other years and other stations. Second, that if confirmed they will indicate that secondary processes are set going in the atmosphere by small changes of solar radiation, which, by altering the atmospheric blanketing effect, magnify in some stations, and reverse in others the natural direct effects of the solar fluctuations. Third, that if such large changes of temperature

are thus caused, investigation may be apt to reveal important effects of solar fluctuations on the winds, cloudiness and precipitation. Fourth, that since the outstanding unexplained departures from mean daily temperatures, as illustrated above for Leavenworth, Paris and Sydney, are seldom of much greater magnitude than the changes which are found by Clayton to be produced by changes in the sun, and as the maximum effects of solar changes follow from one to five days after the cause, depending on the latitude of the station, it may be possible that a very large proportion of weather changes will become predictable for some time in advance, if daily measurements of the solar emission shall be secured. Fifth, that since daily solar-constant measurements of sufficient accuracy can only be had by establishing several new observing stations in the most cloudless regions of the earth, at an initial expense of from \$5,000 to \$10,000 each, and continued expense of from \$5,000 to \$10,000 per year each, the occupation of this promising field in forecasting is likely to be deferred until after the war is over.

At present the Smithsonian Institution is alone making the required measurements, at Mount Wilson, California, and Hump Mountain, North Carolina. Weather conditions are not sufficiently favorable at either station to warrant the expectation that on half the days in the year the solar radiation will be properly measured. A projected station in South America has been deferred on account of war conditions, but may soon be occupied. A bequest of half a million dollars to the Smithsonian Institution would enable it to handle adequately this apparently exceedingly important problem.

EVIDENCES OF FULL MATURITY AND EARLY DECLINE

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WE are blessed in America with a between season known as Indian Summer. As the days of autumn grow cooler to colder, somewhere toward the winter comes a genial glow in the air, a seductive restfulness, a luxurious period of weeks in which to bask gratefully in whatsoever surroundings one may be. This contentful interlude is said to be devised for the purpose of encouraging the primitive redman to do his undone chores, to catch up on his neglected provisioning against the pitiless winter. Just such a tranquil span may be reckoned upon when the sun turns and passes the meridian and looks into the face of man as he fronts the setting.

Not all the pageantry of early aging or over-maturity are inflictions to be endured. A peace oftentimes supervenes; a shedding of earlier anxieties; a settling down to an even progress. These are halcyon days in which the heretofore tempest-tossed one may look about, stretch his limbs and give interested attention to what goes on about him.

For most persons the hurly-burly is by then pretty well over; a position of advantage has been reached, the fires of life burn not so brightly, 'tis true, but more evenly. The machinery has become a little worn, weaker in spots, but all bearing surfaces have been abraded to meet each other in a smoother adjustment. There is less friction and far less racking.

When that blessed time has come, one's children are presumably able to look out for themselves; some have left the nest; at least anxieties on their account are subsiding or less urgent. Life's struggles are pretty well settled and progress is accruing.

The body cells are then less irritable; nerve centers are more stable; there is less tension in all voluntary muscles; a general evenness in action has set in. Whatever be our position in the procession of life we know pretty well we must now be content with it, accept such modifications and betterments as we are able to bring about by making the most of what we

have got, what we did with our foundations. Uncertainties are, or should be, nearing their end. From this time on our bodies as well as our careers can only be conserved; not radically changed for better or for worse.

Whatever destiny remains in our hands, to shape it is the part of wisdom to meet that destiny with a serene brow, with thankfulness for what we have enjoyed and are able to retain, to accept the position in life which we have won, to cross off our losses and forget them. It is a time to take account of stock and make up the report upon our trusteeship of that splendid heritage, our body and our mind. Satisfactions will be the greater if we have given reasonable care to the increments of our talents. Some part of a mature philosophy should then have been achieved, due to so much of mental serenity and discharge of duty as we have been able to command. Then we can pass on to other stages of our biologic evolution; of our journey to the grave.

To those who view their past as a mere category of mental achievements the account may not seem large. Compared with those who merely aimed to survive, to "get along," ours is certainly more varied, more vividly absorbing, more worthy of review or exhibition. We should never undervalue our body, however; it is of paramount subservience to or rather correlated with the mind.

Unless we have kept our material parts in good working order to enfold and maintain our soul or spirit, we have failed to "acquire merit" or to sustain the makings of a healthy self-esteem. Few indeed should fail here; no good reason exists for any one to so fail.

The phenomena of overful maturity and early aging deserve to be known, philosophically accepted and serenely assessed. From early maturity to late old age the characteristic retrograde changes are those of wearing out of structures. This wearing out takes place throughout the whole range of actively changing parts, in those which are constantly at work, and is especially seen in those which work incessantly to keep the body going. The constant wear and tear is shown most in the heart, the blood vessels, kidneys; and back of these come the great regulators of life, the ductless glands.

Back of these also lie those fairly stable structures the brain, and nerve cells. It is being demonstrated by the life insurance experts that breaking down (degenerative) diseases are markedly on the increase among all sorts and conditions of men, in all lands and under all circumstances civilized or savage.

One half the causes of premature death are shown to be capable of being prevented as are the infections which now happily are coming under better control. So you see in the final count behavior is paramount; blameworthiness is the reason for most decadence.

Hence it is of the utmost interest for each one of us to learn how we can become aware of the earliest origins, of backward stepping, the parting of the ways. Unfortunately, most phenomena of degenerative diseases are so insidious, give so little warning, that the only wise course is to expect their occurrence, to be vigilantly on our guard against them and live so sanely as to avoid the worst of them.

In order that any one shall protect himself he must learn his own peculiarities, his specific needs, and remodel his life when necessary in accord with the findings. Here instinct helps us much. We are fundamentally aware of what it is right to do and what is necessary to avoid doing. Experts tell us that whereas large gains are being made, notable victories gained, in combating tuberculosis, pneumonia, typhoid fever and other infections, there is a steady increase in the "degenerative diseases" and in the following order of frequency: liver and digestion, apoplexy and nervous diseases, heart, kidneys and urinary diseases. Cancer is not only gaining, but we do not yet clearly know in which directions to proceed to combat it successfully.

Some of the earlier senile phenomena are physical and others mental. Let me mention a few of each. Many can not always be distinguished from evidences of mere culpable neglect of normal precautions or due to laxities in attention.

It may occur that on physical exertion the heart beats noticeably, *i. e.*, one becomes aware of its throb and change in its rhythm or force. It may be over quick or "thumpy"; the breath becomes short for no reason or from slight cause. The digestion becomes more insistent to be indulged or pampered; appetite is more discriminating; taste (usually, not always) more exacting. Hence one's enjoyment of food is greater in one way for qualities and less for the satisfaction of healthy hunger. Appetite is often far too great for safety. Gross feeding occasionally tends to master judgment and must be wisely supervised. Cravings, fictitious longings, habit formed desires for non-essential or hurtful things, must be suppressed.

Since one's whole life tends to become more deliberate, the impulse to stool, to relieve the bowels is now better heeded, time is taken, opportunity welcomed and provided for.

The youthful energetic spring (vulgariter "pep") no longer joyously activates the muscles. They may be very serviceable, but their energy is no longer exuberant. Weariness is readily recognized and more rests are, or should be, provided for. Fatigue states are not, or should not, be permitted to get too severe; self mastery must not be impaired by the strained attention of subconscious worries. One becomes by this time at least less of a fool in the matter of prodigalities of energizing; hence is ready to take precautions to avoid exhaustion.

Aches and "pains in the bones," really old age changes in the muscles, obtrude themselves. This means that the muscles cells are becoming less vigorous; are being replaced by fibrous tissue and the sensory nerve fibers are pinched by the stiffening structures. To be sure, gouty persons and those who have suffered minor infections in the joints do have some pains in them; they may become slightly swollen and tender on motion and later tender to touch, to pressure or to slight blows. Often finger joints are tender in the morning and this wears off later in the day. However, stiffness with over-sensitiveness to touch as well as motion is a natural evidence of old age changes.

At first these "reminders" are readily overcome by "warming up" at work, by moving freely the arms, fingers, by gentle exercises, walks or work. We may learn of these sensitive joints for the first time to our surprise by some extra pressure or a blow. Many latent tendernesses are due to a condition exceedingly common in middle age, of over-sensitiveness of the junctures of the muscle and fibrous attachments covering them which run into the tendon sheaths. These over-sensitive states are readily overcome as a rule by giving them something healthy to do. They affect the head, being the source of certain forms of headaches; the neck, shown on turning quickly or forcefully; also in the muscles of the eye when put upon a strain.

The urinary organs in older men are peculiarly liable to get out of order: rising at night to pass water is common and may be due to acid or irritating urine, irritable bladder (cystitis, etc.), to old urethral structures or to that scourge of old age, prostatism. This last is a loss of elasticity in the structures of the prostate gland, a mass of tissue surrounding the base of the urethra (outlet to the bladder). This demands prompt and radical attention; it can always be relieved and occasionally cured. If neglected it goes on to a hideous distress.

In women, especially in those who have had children and in whom the pressure of the pregnant uterus has overdistended the bladder, or in whom injuries to it have occurred in par-

turition, urination may be greatly disturbed and control lost. Leaking of urine, only too frequent, needs early and thoroughgoing attention. The act of urination is easier in later life in both males and females, which may also be a source of harm, causing the impulse to void to be disregarded. Urine accumulates, the bladder becomes distended, therefore dilated.

On the other hand, difficulties in voiding urine or the complete emptying of the bladder tends to apathy and neglect.

As the energies subside, unless there be some stimulus, some object or ambition to keep one interested in activities, the tendency is to omit care of the person, of suitable hygiene, and to fall into indolent habits; indeed, to become a nuisance to others. The one imperative need for the aging is action, wholesome doings, use of parts, changing of scene and circumstances. "Vanity is the mother of all the graces" and pride is a boon to old folks.

One notable alteration occurs in over maturity which, though merely esthetic, is significant. Emanations from the skin become offensive; fatty acids are formed producing different, repugnant or fetid odors. A dank mustiness replaces the normal pungency. To overcome this skin friction is more effective than mere bathing. Many devices are offered to neutralize these malodorous effluvia, but the best one is bodily hygiene and activities. The sweat often markedly increases or is suppressed; if insufficient the thyroid action is depressed. Reasonable activities are always needed to keep the skin action normal.

As old age advances so do heat making powers subside. Help is then needed to maintain combustion. The temperature sense becomes deranged. Chilliness is readily felt, artificial heat is craved; greater weight of clothing, warmer underwear is needed. Insensitiveness leads to evil effects of undue exposure, to chilblains, also to loss of local vitality, occasionally to gangrene. In others heat loss is impaired, the skin then acting badly, hence the surface is hot and dry, unrelieved by perspiration.

Changes in the ligaments and bones occur in the middle aged as well as during decline, inducing deformities in joints, particularly in the fingers and toes. Earlier defects become accentuated, such as bunions, fallen arches, flat feet, hammer toes. In old men there is usually a slouch, a drooping of the shoulders, a shrunken chest, bent knees. During maturity this disfiguring state too often is seen, mainly due to carelessness. In the old it then is also a weakening of the erector muscles of

the back. In women this is more rare, they being supported by vanity, a desire to maintain a good appearance.

Habit attitudes are often the chief factors in acquired deformities, notably desk workers, drivers and others who must sit for long periods on uncomfortable seats. All these deformities are mainly due to carelessness and can be prevented or limited by reasonable care; intelligent attention; a wish to keep a good form. This subject of posture is of real economic as well as of esthetic importance, as the tissues lose their pristine tone.

The disks of cartilage between the sections of the backbone in old people atrophy, but this comes late and need do no more than cause a shortening, not necessarily a bending. One of the most graphic and conspicuous features of aging, often seen in late maturity, is a slouching, slinking walk, uncertain feeble steps, a tottering-shuffling gait. This is directly due to loss of elasticity in the muscles (or rather aponeuroses and fibrous attachments) of the legs. Of course a relative degree of weakness contributes, but both can be alleviated; the one by passive stretching of the limbs, the other by attention to nutrition.

The teeth tend to fall out by reason of the shrinking of their sockets. Of course caries and pyorrhœa and other diseases contribute to dental losses. There are those who claim that tooth loss is a wise provision of nature to warn against the continuous use of meat and solid foods. Be this as it may, the best advice is to get rid of all suspicious teeth, especially any which have abscesses at their base and to "buy a store set"; chew your food thoroughly and add to your strength and length of days.

Nothing so marks the turning point of vigor, of efficiency, in short the advent of senility (abnormal old age), as loss in the organs of special sense. Time was when the lenses of the eye had begun to flatten and near vision was impaired, a man or woman was practically relegated to the scrap heap. Now we know that by the single device of wearing correcting glasses the years of usefulness, not to speak of progressive intelligence and happiness, become indefinitely prolonged.

One point should be emphasized here: A large proportion of degenerative conditions of the eye, disablements of diverse kinds and degrees, can readily be prevented by having the eyes examined early and in wearing correcting glasses and other devices to bring vision up to normal by mechanical and other adventitious aids. This is particularly significant in the case of cataract. Let brain workers, especially literary men, take notice.

Even to-day one meets dear simple old bodies who confidently repeat the errors of a half century ago (when the light of ophthalmology had scarcely dawned) that they personally *avoid* the wearing of glasses as long as possible, seeming to enjoy the condition of having performed a meritorious duty. Worse than this archaic folly is the arrogant conceit of those who refuse to have obvious and glaring defects in their own eyes corrected, or (most unforgivable) those of their children.

No one agency so fully compensates losses of capacity and capability due to aging as the use of properly fitting glasses to correct errors of refraction. Hearing is only second in importance in this connection to vision. Conservation of hearing is of paramount importance. Knowledge of the causes and cure of deafness has grown *pari-passu* with that of blindness.

Of the two sense organs, touch and smell, both of which become impaired as aging progresses, we need not dwell upon at this time. Taste, however, is of deep significance as years go by. It bears directly on the subject of nutrition, choice of foods and dietetic habits. A smaller amount of food is required after full maturity. The structures in middle age are all fully developed, or ought to be; hence structure building foods should be taken in smaller amounts. Taste for them naturally subsides, an instance of adaptation to changed conditions of structure and function. The hydrochloric acid and stomach juices are less, hence a craving for pungent highly stimulating substances like pepper and salt usually remains. Acids are craved, and fruit acids are of much value. Alkaline and insipid foods are disliked.

Decomposition in the intestines is increased though the products give less discomforts. The total amount of urea and uric acid eliminated is far less in old age; only about one half the CO_2 is exhaled as in early maturity. Fats are not needed, they are the chief fuel, hence the bile is diminished.

Disease processes and their effects peculiar to the descending epochs must be reckoned with in addition to the normal and usually recurring changes of late maturity and aging. In every one slight injuries have occurred in earlier years, some of which leave strains, scars, alterations in structures, which may give no evidence of their existence till weaknesses and deteriorations in structures set in, as senility approaches.

Some of these injuries (traumata) induce habits of wrong use or disuse which limit or vitiate normal action or function. Effects may be shown in peculiarities of motion, of speech (articulation), of attitude, of energy or of indolence.

Attitude errors, posture peculiarities or anomalies, commonly result from slight injuries. Also errors of gait, limps, of placing the feet arise, many of which can be corrected or eliminated. Acquired faults from ill fitting clothes, corsets, shoes, collars, belts, braces, occur in many persons unless vigilantly watchful.

Habits of using canes for support, even of crutches, may be the result of slight injuries, long recovered from. Fear, apprehension, cause these to remain, and the need for them is psychic and fictitious. There may be some local rigidity, some limitation of normal motion, quite curable. These conditions form a fertile psychopathic ground for quacks, charlatans.

Aching tiredness is common in those who remain much in wrong attitudes or in disease. The cure is simple and imperative, abundant varied, wholesome action. The older these errors are the more difficult to eradicate; the more difficult to reeducate to normal uses.

A BOTANICAL TRIP TO THE HAWAIIAN ISLANDS. II.

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LANAI

A few days were spent on Lanai as a guest of Mr. George Munro, manager of the Lanai Ranch. Mr. Munro, an amateur botanist, familiar with the flora of the island, accompanied us on our trips and was of great service in bringing to our attention the rarer plants. The eastern part of the island runs up into a forested ridge, the highest point of which is about 3,500 feet (Fig. 31), the eastern slope steep and broken with precipitous gorges, the western slope gradually descending to a dry grassy plain. A species of prickly-pear cactus (*Opuntia megacantha* fide Dr. J. N. Rose) has become established here over wide areas and also on the dry regions of other islands (Fig. 32). *Paspalum dilatatum* is proving especially valuable as a pasture grass on the mountain slopes.

MAUI

Maui, the second largest island of the group, is divided into two mountainous masses with a low isthmus between, the two parts being known as East Maui and West Maui. Our investigations on West Maui were conducted from Lahaina on the west coast (Fig. 33). Through the courtesy of Mr. L. Weinsheimer, manager of the Lahaina Sugar Plantation, we were able to visit the highest peak, Puu Kukui, the summit of which is 5,788 feet. Mr. Munro accompanied us on this trip. We ascended the mountain as far as was possible with horses. The trail became so bad that the pack horses were mired and could go no further. The supplies were carried about half a mile further up, where camp was made, the horses being tied in the mire until the third day, when we returned. The tents were pitched in a small opening in the woods, but there had been so much rain that the ground was very soft and soon became mire all around the camp. The trunks of tree ferns were cut and placed in the paths to walk on. The tents were pitched in the rain and no fire was possible until the evening, when enough



FIG. 31. LOBELIA IN HUMID FOREST NEAR SUMMIT OF MOUNTAINS, LANAI. A common climbing fern (*Gleichenia*) in foreground.

was made to prepare tea. The following day we made the ascent to the summit, returning to camp for the night. It rained nearly all the time and the trail was very wet and muddy. The most interesting feature of the vegetation is an open bog near the summit, a type which we found later on Molokai and Kauai. The bog is devoid of trees and large shrubs, though there are some small inconspicuous shrubs lying close to the surface (Fig. 34). Many plants form tussocks raised above the general surface. One of the most conspicuous of these is a sedge (*Oreobolus furcatus*). Three species of



FIG. 32. A CACTUS FOREST ON LANAI. The cattle have grazed off the lower branches.

Panicum are tussock-forming, *P. monticola*, *P. imbricatum* and *P. isachnoides*. These species are peculiar to the bogs. The most conspicuous plants were a species of *Lobelia* (*L. Gaudichaudii*) four to six feet high, with a pyramidal panicle two feet long of large showy cream-colored flowers, three to four inches long, and a species of *Wilkesia* (*W. Grayana*) similar in size of plant and inflorescence, with heads nearly an inch in diameter.

On East Maui is the famous Haleakala Crater said to be the largest crater in the world. Through the courtesy of Mr. Louis von Tempsky and Mr. S. A. Baldwin, of the Haleakala Ranch, we were able to spend four days in this crater. We remained one day at Idlewild near Olinda, on the north slope of Haleakala. Thanks to a pipe line, we were able to penetrate



FIG. 33. A MOUNTAIN GORGE NEAR LAHAINA, showing the steepness of the valleys.



FIG. 34. A SMALL OPEN BOG NEAR KAHOLUAMANO, KAUAI. Forest in background.

the humid forest for four or five miles. One of the plants found on the slopes of the deep wet ravines of the islands is *Gunnera petaloidea*, with huge circular leaves three or four feet in diameter (Fig. 37).

We descended into the crater at White Hill, the rim here being about 10,000 feet altitude (Fig. 35). There is here a



FIG. 35. HALEAKALA CRATER FROM WHITE HILL, the pass at the west margin (10,000 ft.). Clouds rolling in.



FIG. 36. SILVER-SWORD. A sterile plant brought from a cinder cone, supported in lava for photographing.

very fine view of the great crater, lying to the east, nineteen square miles in area, with many cinder cones within. One of the most interesting plants found here is the silver-sword (*Argyroxiphium sandwicense*), a member of the family Compositæ (Fig. 36). The narrow sword-like leaves, borne in dense hemispheric clusters, are covered with a silvery appressed tomentum that glistens in the sun. From the center of the cluster arises the flower-stalk bearing a large number of heads of flowers. The plants grow on the slopes of the cinder cones far above other vegetation and look at a distance like a flock of sheep. The silver-sword in a somewhat modified form grows on Mauna Kea and Mauna Loa but not in abundance. While climbing the western wall of the crater I had the misfortune to fall about fifty feet, escaping death by a very narrow margin.

MOLOKAI

This island lies with its greatest length east and west. The eastern half is mountainous (Fig. 38), the mountains ascending steeply but evenly on the south side, but dropping off very precipitously on the north side. The western half, more level and much drier, is occupied by the Molokai Ranch. The leper

settlement is on a peninsula on the north side of the island below the mountains. On the summit of the ridge is an open bog similar to the one on Puu Kukui.

KAUAI

Kauai, the Garden Island, the most northerly and the oldest geologically, is nearly circular in outline and rises somewhat uniformly to the central highest point, Waialeale, 5,170 feet altitude. The erosion on this island has been extensive, resulting in deep gorges and canyons. We visited Olokele Gulch (Figs. 39, 40), a very picturesque canyon a few miles from Waimea, but the main trip on the island was the ascent of Waialeale. This is a rather inaccessible peak and has been visited by few botanists, the first being the Austrian, Dr. Wawra. Professor Rock had ascended the mountain a few years previously and we were fortunate in having him with us



FIG. 37. A LEAF OF *Gunnera petaloidea*, brought down to Idlewild from the humid forest along the Olinda pipe line, Maui, near Haleakala.



FIG. 38. SOUTHERN MOLOKAI, NEAR MR. CONRADT'S PLACE, PUKOO. Looking up one of the steep valleys toward the central range.

on our trip. An account of the trip will be given somewhat in detail as it illustrates the difficulties of botanizing in wet regions.

We made our headquarters at Kaholuamano, a mountain house belonging to Mr. Francis Gay. The party consisted of Professor Rock, Albert and myself, and the Hawaiian guide Kualu, who has made the trip several times. We started from the mountain house in the forenoon, going with horses as far as the trail permitted, a distance of perhaps three miles. A Japanese helper took back the horses, but was to return to the same place on the third day to meet us. We then set out on foot, carrying our supplies on our back. We had food for three days, a meagre set of cooking utensils, blankets, extra change of clothing throughout, and a small camera.

The upper part of the mountain is very wet. A rain gauge is maintained on the summit which is read once a month. As much as 600 inches per annum have been recorded. Consequently the trail is very muddy and one often sinks to the knees, even when picking one's way. As the trail is traversed rarely except the monthly trips to the rain gauge it is not kept well cut out. About a mile of the trail is in the bed of a mountain stream. We were all wet through from head to foot as it was raining most of the time. The first night was spent in a cave (Keaku Cave) on the side of a very steep hill or cliff. The cave is an ancient one that was occupied by the natives on trips to get bird feathers for use in making royal robes. It is high up on the side of the cliff, perfectly dry, but without an approach save a steep path at one side and drops off suddenly at the front. The depth is only sufficient to give shelter to a few people lying down. In the cave we found a supply of white paper "inner sheets" left there by Professor Rock five years before. Fire wood is cut by each party occupying the cave and stored, so as to be dry for the use of the next party.

On the second day we started for the summit. A large open bog occupying several square miles stretches from the summit of Waialeale northwest along the plateau back of the main ridge, called the Wainiha Pali. This ridge is very steep on the northeast side, but gently sloping or almost level on the southwest side. The bog is about ten miles long and one or two miles wide. The plants are about the same species as are found in similar bogs on Molokai and West Maui. The bog extends to the summit, over which the cold wind blows with great violence. Here and there are pools and ponds. The cold wind blowing on our wet clothing chilled us thoroughly and we were glad to commence our return.

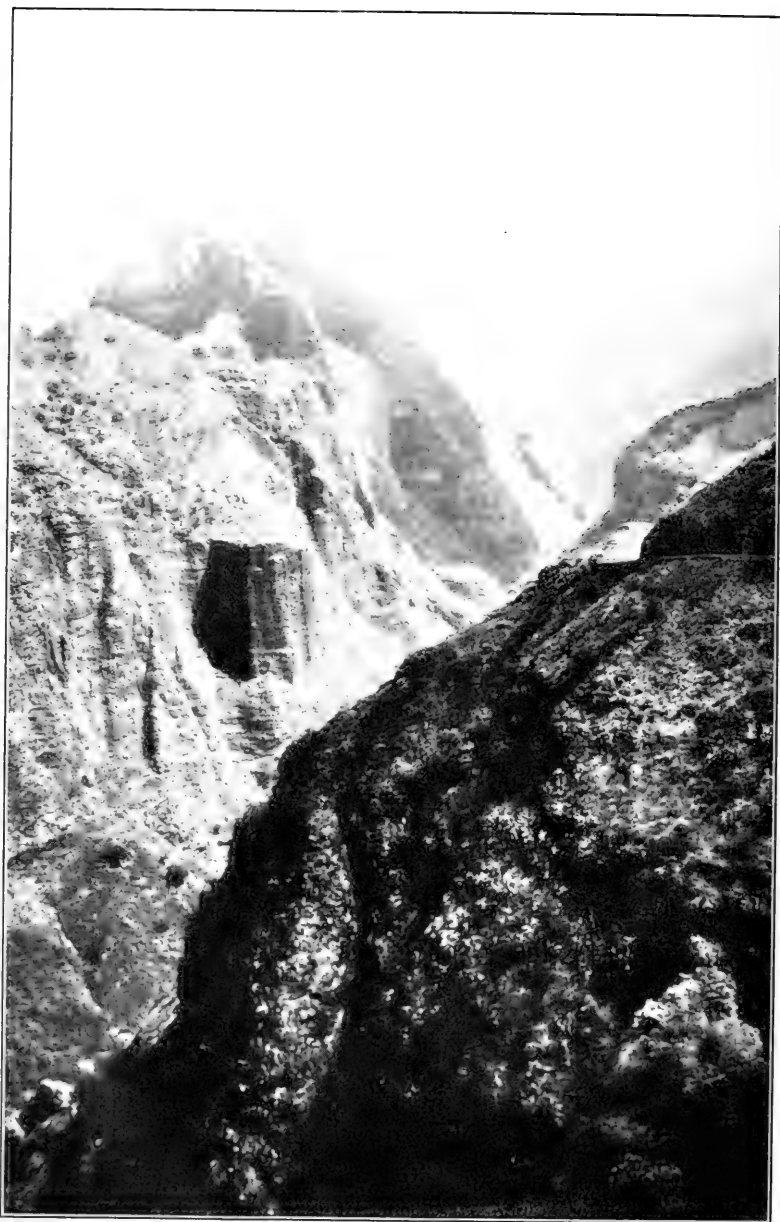


FIG. 39. OLOKELE GULCH, KAUAI, showing the effect of erosion.



FIG. 40. OLOKELE GULCH, KAUAI. The trees with light-colored foliage are Kukui (*Alcurites moluccana*).

The second night was spent at the cave and on the third day we reached Kaholuamano. The return was even more arduous than the outgoing trip. The load was heavier because of collections, which were not offset by the consumed provisions, and furthermore the rains had been heavy and continuous, so that the streams were higher and the trail more water-soaked.

A few days were spent at the mountain house, collecting in the vicinity. A very interesting species of *Poa* obtained on one of the ridges has been described by Professor Hackel as *Poa siphonoglossa*. It grows in large tufts on the steep slopes just below the top of the ridge. The numerous culms are several feet long, leafless, green, and have the appearance of a



FIG. 41. REPRESENTATIVES OF THE LOBELIA FAMILY: peculiar palm-like forms.

bullrush except they are lax and hang down the bank. The flowering culms are shorter and bear leaves to the summit. The spikelets and the flower culms look like those of *Poa*, but the rush-like sterile culms are different from any known species of that genus.

One of the interesting families of the Hawaiian flora is the Lobeliaceæ, represented by about 100 species belonging to 6 genera. The numerous arborescent species are very peculiar and characteristic. Many of them form slender trunks like small palms, crowned with a large cluster of long narrow

leaves (Figs. 41 and 42). The trunks of some species are as much as 30 or 40 feet high and the large bright-colored flowers are sometimes remarkably beautiful.

The ferns of the Hawaiian Islands are numerous in species and individuals. They are the dominant feature of all the wet forests. Three species of tree ferns (Fig. 43) of the genus *Cibotium* are found and in some places form extensive forests.



FIG. 42. AN ARBORESCENT SPECIES OF THE LOBELIA FAMILY (*Cyanca* sp.), a group highly developed in the Hawaiian Islands. Forests of central Kauai.

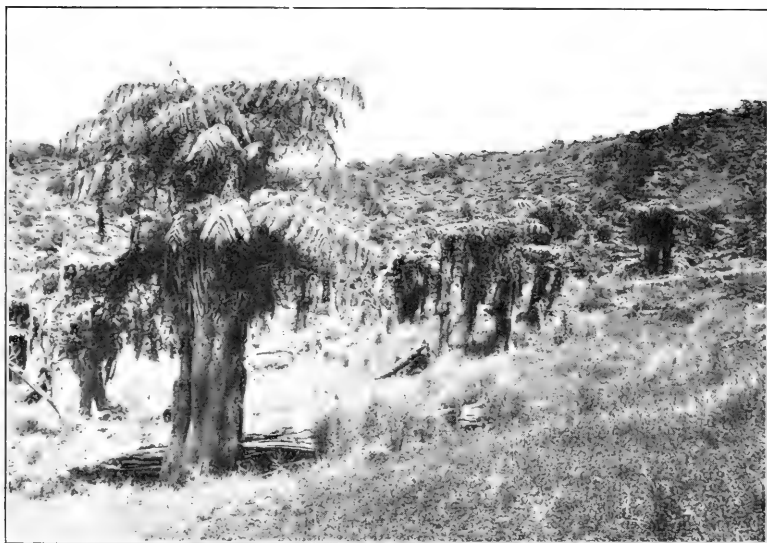


FIG. 43. TREE FERNS (*Cibotium Menziesii*) IN THE KOHALA MOUNTAINS. Those in the foreground are in a pasture and the surrounding vegetation has been kept down. In the background the ferns are mixed with other vegetation in a dense mass.

These produce at the base of the stipe a great ball of brownish-yellow wool called pulu by the natives and used by them for stuffing pillows and mattresses. One species (*C. Menziesii*) is shown in Fig. 43. Contrasted with the tree ferns are numerous small epiphytic forms, some species with fronds only an inch or two long. The ferns and fern allies number about 170 species.

THE INFLUENCE OF ANTHROPOLOGY UPON HISTORY

By WILSON D. WALLIS

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THE definition of history as a record of past events suggests the advertisement of a certain firm which promises to teach one how to train the memory. This man, it says of the discoverer of the system, can give the size of every city in the United States having a population of over 5,000, and can give the dates of two thousand historical happenings. This Cinquevallian feat of memory may afford the possessor, and others who enjoy such harmless pastimes, considerable amusement; but certainly no one who has burdened his poor mind in this way can hope to be of any use to society. He has learned figures, but not history; he might make a mathematician or a guide to railroad schedules—he certainly could never become a historian.

For the sake of history itself it is entirely regrettable that the insistence on a series of dates as the groundwork of history was not carried at once to its logical conclusion. It is not enough, such logical insistence would tell us, to know that the Hegira occurred in the first half of the seventh century; we must know that it was in the year 622. Nor is that enough. We ought to know that it occurred at 6:15 P.M., on August 3, 622. No less exactitude should be demanded of those who find the beginning and end of history in dates. They may then take their place with those earlier Biblical scholars who declared the date of the Creation to be the year 4004 B.C., October 28, at four o'clock in the afternoon.

Dates are comparatively unimportant for two reasons: In the first place, simply as so many isolated dates they add no more to our knowledge of an event than if we described the temperature rather than the time of year when they occurred. After all, why should the historian have his eye always on the calendar rather than on the thermometer?

Furthermore, dates are comparatively unimportant because they are only relatively true. Indeed, dates are more false than true; they are more often misleading than enlightening. Take, for example, the French Revolution. The older histories tell us

that it began in 1789. No modern historian would be so clear-cut. The French Revolution began—who would say when it began? It certainly had its roots in an intellectual revolution, in a spirit of change, in a new attitude of mind, in new philosophies of life and of society, and in new foundations of human and political rights. It matters not what important historical event you select, you can not give it an exact date unless you do this arbitrarily and in defiance of its prior existence and development. The reason is plain enough: they are not events, in the sense that they are mere happenings. Rather are they but the climax of a development, the crest of a wave which is important, not because it is a crest, but because there is a wave back of it. The amplitude, the sweep, and the direction of that wave rather than the crest itself constitute the importance of the historical event. Might we not, indeed, say that historical events are important just in so far as they are not mere happenings, isolated episodes, but represent one phase of some deep-lying and long-continuing development? Such, at least, I take to be the meaning of history, if we are to give up dallying, like mental sleight-of-hand performers, with so many happenings and dates, and instead take our subject seriously and hope to make it profitable.

What, then, does anthropology have to do with this conception of history? I reply that it both has had, and still does have, a great deal to do with it. From anthropology more than from any other quarter, not excepting history itself, has come the conception of history as a continuous development. Whereas the older history treated human progress as going forward by so many leaps and bounds or as a succession of unrelated happenings, anthropology has developed and vigorously applied to almost all phases of human life the conception of a gradual development, of a progress that differs in rapidity and may have many a set-back, but is nevertheless essentially continuous throughout. If one may be permitted the comparison, from the first, history has thought of man as advancing after the manner of the frog, while anthropology, from the first, has insisted that he has one foot ahead only when and because the other is behind. Anthropology has largely accomplished its task through observing that human nature is much the same the world over, and that what it is to-day is largely because of what it was yesterday. We are gradually coming to see that history is one continuous, unbroken thread and not a vast collection of fragments.

From anthropology history has gained more than this idea

of human life as a continuous development. It has taken over from anthropology a method of interpretation which is a corollary of the theory of continuous development. This corollary is that civilization, in all ages and in all stages of development, has a remarkable conservatism. Social life, like a physical body, tends to remain in its original condition. Let it start moving in one direction and it is easier to keep on than to stop. This application to history of a simple and long-recognized law of physics has called for many a reversal of the current interpretation of events. It gives a new insight into causes. We used to think it obvious enough that a people adopt or continue a certain institution because they like it; we now see that there is as much truth in the converse—they like it because they adopted it and continued it. It is just as true that we like democratic institutions because we have them as that we have them because we like them. I do not believe that any historian professes to have discovered this principle. It was the insight of an anthropologist, a friend and contemporary of Darwin, E. B. Tylor, who first made this clear in his "Primitive Culture," and "Early History of Mankind." He showed that many beliefs, customs and institutions can be given no sufficient explanation without the historical setting, and this exhibits them as survivals of a previous civilization of which they are the outstanding remnants. The historian is coming to make more and more use of this instrument of interpretation, and with increasingly valuable results.

So much for the contribution of anthropology to history by way of methods of interpretation. What has it contributed in actual material, in the data that must be used?

Here, too, the contribution of anthropology has not been negligible. It has enlarged the horizon of history at every point, but most of all at its beginning. What the anthropologist calls pre-history is as much history as ancient history or medieval history is history. In all cases it is the reconstruction of the past from existing documents. It matters not whether these documents be written or unwritten. In fact it is often much easier to interpret the unwritten than to interpret the written. Prehistoric anthropology has given us a hitherto unsuspected insight into this nebulous past. The vistas have not only lengthened into tens of thousands and even hundreds of thousands of years, they have also been given a content; they are no longer barren, but tell a story. That story discloses to us the long processes by which crude men of the stone age have fashioned their crude weapons, gradually improving upon the

experience of the past. This improvement can be traced in some detail as the implements become more highly specialized and give rise to new types which, in turn, are improved and throw off further new types. Even the artistic ability of the man of tens of thousands of years ago has been preserved for us. We know also the story of the domestication of the animals, which first served him as food, and of the care of those valued plants which later he assiduously cultivated. But the details of this story can not be given in a few words.

In another and distinct manner anthropology has been a valuable maid-servant to history, namely, in the understanding it has given of those peoples with whom civilization has had most to do and which have had most to do with it. So far as American history has been influenced by the Indian tribes, this portion of it is as much anthropology as history. When one reads the average historian's account of these tribes there is reason to regret that no larger element of anthropology has gotten into it, for most of these accounts are three fourths misconception. Moreover, every European nation has been largely affected by the ideas or customs of primitive peoples, within or without its bounds, and these influences are usually best estimated by the anthropologist.

It remains to ask to what extent writers of history have, at the same time, been anthropologists. In this matter, as in most others, the Greeks deserve first mention. Herodotus, the Father of History, has equal claim to the title of Father of Anthropology. I know that he has also been given the third title, the Father of Lies; but a better understanding upon our part of the conditions which he describes has tended in the main to confirm rather than to discredit him. He was the first one to grasp the fact that to know merely the history of one's own people is not to know that history. Here, as elsewhere, comparison is the mother of clearness and the true dimensions of a subject can be seen only when that subject is viewed through some perspective.

Herodotus realized that if he wished to discover the causes of the Greek and Persian wars he must go to the Persians as well as to the Greeks. He knew that those causes could not be explained by a few outstanding facts, for this would be to mistake the occasion for the cause. He, therefore, studied Persian customs and Persian dress, Persian superstitions, religions, politics, and all that went to make up the character of the individual and determine the nature of the civilization. He may have made many mistakes, but much can be forgiven the pioneer.

Herodotus's faith in the value of the comparative anthropological method was not solely academic. He himself visited the Mediterranean peoples and attempted to fathom their civilization. He gives us an intimate account of many Egyptian beliefs and customs. While this account revealed to the Greeks a new civilization, it must at the same time have shown them their own civilization in an entirely new light. They had been looking out upon the larger world through the medium of their own culture. Herodotus enabled them to stand without their own world and look upon it from a new standpoint. He thus objectified for them the intimate conditions of which they were so thoroughly unaware, just because these conditions were the glasses through which they had been looking. Their state of surprise must have been comparable to that of M. Jordain when he suddenly awoke to the fact, hitherto unsuspected by him, that he had been talking prose all his life.

Herodotus's comprehensive grasp of anthropological method is surprising. In his account of the Scythians, for example, he gives us nearly all the categories that we find utilized by a trained anthropologist of the present day. He has not worked out the details with as much care or insight as our contemporary investigators; and it would be nothing short of a miracle if he had.

After Herodotus the most noteworthy anthropological historians were Strabo and Diodorus Siculus, from whose studies of the tribes known to them we glean our most valuable information of the ruder Mediterranean peoples. Each of these writers is to-day an invaluable source of information for the anthropologist as well as for the historian.

To the Romans, also, we are under especial obligation. The *Commentaries* of Cæsar, the *Agricola* and *Germania* of Tacitus, are good anthropological works as well as good history. The great historian of the German peoples, the late Lamprecht, is insistent that German history, to the present, is but the unfolding of germs of development lying latent in these crude Teutonic tribes of which these writers tell us at once so much and so little. Indeed, it would scarcely be going too far to say that without the anthropologist Tacitus we should not have had the historian Lamprecht, just as we would not have had modern Germany if there had been no Germanic tribes. The study of these tribes is essentially anthropology while the study of German States is essentially history. But who will say where the one begins and the other ends?

In Plutarch we have a good example of the comparative

historian who also attempts the anthropology of his own people. If his *Lives* constitute history as well as biography, his *Questiones* is certainly anthropology. As Lucretius was the first to recognize and picture the evolution of civilization, so Plutarch was the first to recognize the importance of survivals and the permeating force of conservatism. His analysis of these survivals gave an insight into existing customs which hitherto had not been suspected.

Unless one class as historians the students of comparative law, such as Montesquieu, Locke, Sir Henry Maine, there was no union of the anthropological and historical interest until the last century. The Spanish theologians had, at an early date, begun their fantastical proofs that the American Indians represented the lost tribes of Israel, and certain English writers, as notably, Adair, continued the ill-founded fallacy; but not until Prescott, Bancroft, Maximilian von Wied, Catlin, Schoolcraft, and a host of American writers, do we find anthropology and history keeping step.

The spirit of Herodotus is, however, still abroad and is settling on the heads of many of our contemporaries; in Germany on the historians of *Kulturgeschichte* and in America on historians of every school. McMasters finds it necessary for American history, Robinson for any history, Breasted and Hutton Webster for their ancient history. A new era, an anthropological-historical era, is dawning.

To sum up: anthropology has brought into vogue new methods of studying human civilization and these have been taken over by history. Its concept of a continuous development has made of history something more than a mere recital of events and has given a clue to the continuity of institutions and customs. It has extended the old boundaries of historical research and has introduced a new perspective into human culture. It has introduced an objective and comparative method which, now that its value has been grasped, will never be surrendered.

THE EDUCATIONAL THEORY OF SOCIAL PROGRESS

By Professor CHARLES A. ELLWOOD

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CIVILIZATION is essentially an acquired trait. Its basis is the accumulation of a mass of habits which are transmitted from generation to generation through custom and tradition. Each generation has therefore to acquire this ever-increasing mass of habits which make up human culture. So far as we know, biological selection can do nothing more than equip individuals with hereditary powers and capacities to acquire this mass of habits from their social environment. There is no evidence which would warrant us in believing that the children born in the most advanced civilization are inherently more civilized than the children born under the most primitive conditions. They are simply born in a more favorable environment in which social machinery aids them to take up the habits, knowledge, standards and values of the civilization which surrounds them. It follows from these simple statements that the methods of continuing and developing human social life in its cultural phases must be essentially of an educational nature.

The educational nature of the social life process would seem to demand, accordingly, more serious consideration than has usually been accorded to it by most sociologists. Whole volumes have been written on social progress with scarcely a mention of educative processes. On the other hand, educators surely need to realize, even more than they have done, that in dealing with education they are treating of a most essential and vital phase of the social life process, and that education has always been and must remain the main method of social progress. Gratifying advances have been made in this direction within the last few years, both by educators and sociologists; but something still remains to be done to bring together and to coordinate the results in both fields. It is the purpose of this paper to endeavor to make a contribution in this direction by considering education as a means of social development and progress.

It should be stated at the outset in discussing the educational theory of social progress that education is to be con-

sidered as a method, not as a cause, of progress. The causes of progress undoubtedly lie in the stimuli in the environment and in the nature of the human individual. To acknowledge this, however, is in no way to detract from the importance of education in the theory of social progress. For in all practical sciences the question of method becomes of as great importance as the question of cause. It is the expansive power of steam which causes the engine to run; but the efficiency of the engine will depend very largely upon the method by which this natural force is controlled and applied in any particular case. So it matters not whether we decide that the causes of progress lie in the stimuli in the environment, or in the energies wrapped up within the individual, or in both; the question of how these causes can be made to work most effectively and harmoniously still remains to be settled.

Our thesis is that the active factors in progress can be most advantageously, economically and effectively controlled in human society by the educative process. We mean by the educative process the whole process of controlling the formation of habit and character, of ways of thinking and ways of acting, in the individual. Formal education, to be sure, may be only a very small part of this process; but, as social evolution has advanced, there has been more and more a tendency to make this process one of conscious and intelligent control. It is of course the process as conscious and intelligent which we take as our norm usually when we discuss education as a means of social progress. Nevertheless, it should not be forgotten that the more intelligent and highly conscious phases of the process have sprung out of less intelligent and less conscious phases of the same process in the course of social evolution. Education in this respect only illustrates what is true of all phases of our social life; namely, that there is an increasing tendency to bring them into consciousness and under the control of intelligence as social evolution advances. It should be needless to remark, furthermore, that the school is not the only institution in which the educative process has been brought under a high degree of conscious control. The home, the church, the press, the public address, illustrate in hardly less degree conscious efforts at controlling the formation of habit and character, ways of thinking and of acting, in the individual. In a more narrow and specialized way, the same thing is true of other social institutions, such as the shop, the factory and the market-place. Wherever we have the use of artificial means of controlling the formation of habit and character in individuals,

we have an educative process. The school, perhaps, has become, in the latest phases of social evolution, the central institution concerned with the educative process; and in so far as it can succeed in coordinating all of the other educational agencies in human society, to that extent what we say of education as a means of social progress will be true of the school also.

The idea of human progress being essentially a process of education is a very old one. We find it first, perhaps, clearly enunciated in Augustine's "City of God." But, it did not become a favorite way of looking at social development until the eighteenth century, when we find such writers as Turgot, Lessing and Herder frequently setting it forth. These writers are usually represented to have developed merely an interesting analogy. They are represented merely as saying that history is the development of the species brought about through the course of instruction which nature affords! This, however, is an unfair representation of the thought of these writers. Rather, it is more clearly expressed in the aphorism of Paley, "All the generations of men are like one man, ever living and ever learning." While the continuity between the generations is here represented to be much closer than it really is, still the meaning is clear enough. History is represented as a process of self-development, the self-development of humanity instead of the individual. It is a learning process, a process in which experience is accumulated and consolidated in the social group, much as it is in the individual mind. In Turgot's famous essay on "The Successive Advances of the Human Mind" progress is thus shown to be the organic principle of human history. Each generation accumulates experience and passes it on to the next in the form of knowledge, standards and values. Thus, as experience is accumulated, and as the race learns through experience, progress is bound to result. Just as the individual grows in wisdom and in character through the experiences of life, so the race is bound to develop. Turgot recognized, however, that there were times of moral and intellectual decadence, but these he contended were not in contradiction with his general principle. They were times when the wisdom of the past was neglected, or when some new situation rendered it inadequate, and mistaken choices were made which resulted in temporary retrogression. Thus, progress might be interrupted, but society was bound to learn from the very mistakes which it made, and in time these mistakes would be corrected, and thus progress resumed. From this, Turgot drew the optimistic conclusion, later developed by Condorcet, that progress was an inherent

principle in human history, and that it was destined to continue indefinitely in the future until human society was perfected.

Now the modern sociologist recognizes such a theory of progress to be altogether too simple, and so inadequate from the standpoint of modern science. Nevertheless, there are elements of truth in this eighteenth-century theory which may make it well worthy of further consideration and development by the sociologists of to-day. Both the cultural evolution of the past and the social progress of the future must be considered to be essentially learning processes. They are processes which involve, we shall endeavor to show, the accumulation of knowledge, standards and values and the imparting of these through educative processes to large masses of men in order to control habit and character.

Let us note to what degree this has been true of past social evolution. Human culture would have been impossible if man were not an animal with a prolonged period of immaturity, that is, with a prolonged plasticity which has enabled each individual to be modified in accordance with the requirements of the life of his group. But this is only saying that human civilization would have been impossible without the educability of the individual. The simplest beginnings of those higher adjustments which we call "culture," and which distinguish the social life of man from that of brutes, are not possible till knowledge and skill can be transmitted from one individual to another. Bit by bit the groups of primitive men acquired knowledge and skill and then transmitted them to succeeding generations by educative processes. This process of transmission is often represented as more unconscious and natural, as less artificial and formal, than we have a right to believe that it really was. For the most primitive groups which have survived to-day give instruction to their children in the making of tools, weapons and in other technological processes, as well as in moral and religious matters. Usually, indeed, skill along these several lines is kept up in a succession of individuals or of families who specialize in these directions. The continuity of human culture from the start, therefore, was maintained largely by educative processes, more or less deliberately undertaken as a means of preserving knowledge and habits which groups found to be of value.

In transmitting the knowledge, standards and values upon which their culture rested, primitive groups had, of course, no such formal institution as the school, although they did make use, to some extent, of formal ceremonies, such as initiation

rites and the like. But for the most part, the basic elements in their culture were imparted by the two primary human groups, the family and the horde, or the neighborhood group. These two groups have indeed been the chief bearers of cultural traditions in all ages. They are still the chief agencies for social education. The education which they impart is by no means to be thought of as like the habituation of the individual to his physical environment. On the contrary, there is constant pressure on the child, in both the family and neighborhood groups, whether in savagery or in civilization, to make him conform his habits, his ways of thinking and of acting, to those of his group. The process is really an educational one, though the methods are not so formal as those employed in the school. But there is the constant artificial control of the formation of habit and character, which, as we have already said, is the distinguishing mark of the educative process.

If continuity in social development was secured in human groups from the start largely by educative processes, it is no less true that changes have always been brought about also largely through such processes. The most significant changes for the better in human society have been undoubtedly due to the processes of invention and discovery. Conditions in the environment have been the stimuli for these inventions and discoveries, but the inventions and discoveries themselves must be considered the real means by which civilization has developed. Now, inventions and discoveries are notoriously the work of a relatively few individuals in human groups, and their utilization by the whole group is brought about by the other members of the group being taught how to make use of them. From the simplest stone implement to the latest automobile, most men have had to learn how to utilize or copy the inventions of the exceptional mind. The whole process of generalizing the use of an invention is, therefore, a process of education. But this is true, not merely in the material realm, but also in the realm of human relationships. New modes of associating and cooperating are invented as well as new tools and machines. Forms of government, law, magic and religion are also, more or less, matters of invention. They have to be diffused also through educative processes, and this is largely the significance of many of the ceremonial usages which attach themselves to those institutions.

A high degree of conscious purpose must not, of course, be attributed to those educative methods which are made use of to spread and perpetuate in social groups new inventions and dis-

coveries, whether these be in the technological or in the more strictly social realm. In the case of those mass adjustments which are made by the group as a whole, however, a higher degree of consciousness enters. Collective conscious changes are made in human groups largely through processes of intercommunication, discussion of ideas and the formation of group opinion. All of this may be justly characterized as a sort of reciprocal educative process conducted by the members of the group among one another. Discussion results in the group gradually discriminating the various factors involved in a situation, in an evaluation of those factors, and in the selection of some of them as a basis for a new adjustment. Social discussion, in other words, is largely a mutually educative process for a group. It brings forth, as Bagehot insisted, the best intelligence of the group and centers it upon the solution of the difficulty. In this way a group opinion is reached, that is, a more or less rational judgment which all the members of the group come to accept whether it represents their individual judgment or not. The power of the pressure of such a group opinion is a commonplace in all reflection upon social matters, and it is obvious that it also acts upon the individual in essentially an educational way.

Thus, it is evident that social evolution in the past, so far as it has been brought in any degree under conscious control, has proceeded essentially by the method of education, and that there is good ground for agreement with the dictum of Thomas Davidson that education is the last and highest method of social evolution. Formal education, the school, is simply the attempt to give this method the highest degree of intelligent direction and control. The formation and preservation of a social tradition, the development of what we call "the social mind" and "social consciousness," all imply educative processes. Civilization itself is the production, transmission and diffusion of the knowledge, standards and values by which men have learned to regulate their conduct. These can not be handed down from generation to generation without educational processes to preserve and transmit them; neither can they be greatly modified or changed for the better without such processes. All the generations of men have been accumulating the results of tested experience. Each succeeding generation has been able to do a little more than its predecessors because it has learned all that has resulted from the experience of the past and it is usually able to add a little to the store of tested experience. If conservation of past knowledge and values in

human society were perfect, it is true, as Paley said, that all the generations of men would be like one man ever learning.¹

It follows that it is the greater or less degree of failure of the educative process which is the immediate cause of periods of moral and intellectual decadence in human society. The failure of the educative process means the failure of the individuals to get proper adjustment to the social life. In every case disintegrative social processes are rooted in the failure to control habits, and so mental and moral character, in individuals. Of course, back of the failure of the educative process to socialize the individual always lie certain general conditions in society which may be regarded as the remoter causes of social disintegration. These are usually social disturbances, such as war, class strife and the development of luxury. War and class strife directly interfere with the educative process, since they divert the energy of the social group to the socially non-productive uses of conflict; while luxury undermines the educative process through relaxing social standards. The failure of the school in the higher phases of civilization to socialize the individual becomes an especially serious matter, since on account of the complexity of social conditions the education afforded by the primary social groups, the family and the neighborhood, is usually quite inadequate. In the higher phases of social life the work of differentiated and specialized educational institutions, therefore, becomes of supreme importance for progressive social evolution.

It is evident that the educative process lies at the heart of cultural evolution and so of human social development. It has been the means by which the civilization of the past has developed. It must be our main reliance for social progress in the future. Those who put faith in other means of social progress, such as revolutions, are destined to be grievously disappointed. Revolutions have swept away obstacles to social progress, but they have never succeeded in effecting permanent progress except as they have been preceded or followed by processes of education. It was the great merit of the late Professor Lester F. Ward that he demonstrated once for all that education is the initial means, and must remain our main reliance, for progress in human society.² Ward saw clearly that the social life of man is of the nature of a developing

¹ The part played by educative processes in social continuity and social change will be found more elaborately described in the writer's recent work, "An Introduction to Social Psychology."

² See his "Dynamic Sociology," Vol. II., Chaps. X.-XIV.

"social mind"; that to control action, we must control opinions, beliefs, ideas and standards. Ward's conception of education, was, to be sure, narrow. He believed that the diffusion of information would in itself suffice to give rise to dynamic opinions, ideas and actions; so that social progress would automatically result from the diffusion of knowledge. But we now see that while "knowledge is power," it is a power that may be used in many different ways; and that only as it is socially directed will progress result from it. Hence, a more socialized conception of education is necessary, to see clearly its power as a factor in progress, than that which Ward gave.

If we accept, however, the broader and more socialized definition of education worked out by scientific educationists, namely, that education is the artificial control of the formation of habits and character in the individual in order to fit him to participate efficiently in the social life, then we may cordially agree with Ward that the key to progress lies in education. For progress is determined by the psychic adjustment of individuals to the social life, by the "social attitudes" which they maintain toward one another. Now, the psychic adjustment of the individual to the social life, in so far as it is not a matter of heredity—and we have already seen that there is little warrant for believing that heredity furnishes anything more than normal human powers and capacities—is obviously a result of his environment. We must have a properly controlled environment for the individual to develop in, therefore, if we wish to develop in him desirable social attitudes. If properly carried out, personal education should furnish to the developing individual such a properly controlled environment; and inasmuch as it furnishes such an environment at the plastic period of life, it is the most subtle and effective form of social control that can be devised. It can secure more difficult forms of social adjustment than can any other human agency. We mean by a properly controlled environment, of course, not simply a physical environment, but even more, a psychic environment of proper ideas, ideals, standards and values. Even the most civilized nations of the earth have only just begun to use education in this sense, as an instrument of social progress. Let us see what it might do if radically carried out.

In the first place, it could make a normal individual many times more efficient socially than he is at the present time. It could not only give him information, knowledge and skill which would make him a useful member of society in general and fit him for vocational excellence in some line for which he is found

by his nature to be best fitted, but it could give him an entirely different attitude toward the institutions and agencies by which social order is maintained and social life carried on. It could give him, for example, a positive and social view of his government, so that he would not look upon it as a mere repressive agency designed to curtail his individual liberty. It could give him a more constructive attitude toward the family, the school and the neighborhood, so that he would more readily cooperate with others in seeking to bring about conditions favorable to social welfare. If the negative attitude of the individual toward such social institutions, which is perhaps prompted largely by his native egoism, could be overcome, that alone would make greatly toward increased social efficiency and progress.

In the second place, such an education could make much more harmonious the relations between individuals. It is just at this point, perhaps, that the education of the nineteenth century failed most completely. This was because it was so highly individualistic; it laid much more stress upon individual initiative and success than upon social service. We are now beginning to see that it may be possible for us to secure a higher degree of social service from the individual without sacrificing his individual initiative and success. If we make the individual more efficient in cooperating with his fellows, whether in the family, in the school, in the community, or in the nation at large, we need not thereby be subtracting anything from those personal qualities which make for individual initiative and successful performance of undertakings. Rather, we are thereby simply transforming individual achievement into collective achievement, which is the substance of social progress. It is idle to say that moral education of the most idealistic sort can not be given in the public school. The social values contained in our moral ideals can be as well taught in the public school, if our education is given a social direction, as any other part of the curriculum. That the ideals of justice, brotherhood and the service of mankind can not be taught in our public schools as easily as the ideals of business efficiency, vocational excellence or commercial success is absurd.

The one thing which is evidently needed to make our educational system an instrument of true social progress, is that it should be more thoroughly socialized. Social service must become the watchword of the school. The knowledge and training which it furnishes should be given a social direction. Education is simply an effective means for the social manipulation and control of ideas, standards, values, of habits of think-

ing and of acting; but if all this is not done with a social end in view, it is quite evident that nothing could so easily destroy the social institutions which conserve civilization, and even civilization itself, as education. It is just because education is such a power for either social good or social evil that we must see that it is rightly directed socially. Nor is there any danger that this will fasten a clamp upon individual development. For the measure of socialization is how far an individual's ideas, habits and character contribute to the increased harmony, efficiency and happiness of mankind as a whole; and an individual development in any other direction than this will surely not profit either the individual or his group permanently. Education becomes a stumbling block to social progress, not when it is given a truly social, that is, a humanitarian direction, but when it is made an individualistic, class or group matter; when, in other words, it fails to inculcate social service in the broadest sense of that phrase.

But we are told that education can not change the "mores"; that rather it is the "mores" of a group which determine what education shall be. Such a conclusion, however, is utterly unwarranted from human experience. In all ages, education has been more or less successful in changing the "mores." We need only take a single example for illustration from our own time. The temperance movement in modern society has been essentially an educational movement. Its success in its war against alcohol has been dependent upon more or less scientific instruction, regarding the physiological and social effects of the use of alcoholic beverages, in our public schools. In other words, without any radical changes in external conditions, but simply through the inculcation in the young of standards and habits corresponding to scientific conclusions concerning the effects of alcohol, the most progressive modern societies seem about to sweep away the use, if not of all, at least of the stronger alcohol beverages, in spite of the fact that the "mores" connected with the use of such beverages were defended by privilege and by vested interests. Hundreds of similar illustrations of the social effects of education might easily be cited from the history of civilization.

The peculiarly encouraging thing suggested by this illustration, however, is that such social effects were brought about by *education based upon scientific knowledge*. So too, if we inculcate social ideals regarding government, law, sanitation and morality, for example, upon the basis of scientific knowledge, we may surely expect them to have an equally great social

effect. The trouble with much of the moral and social instruction in our schools in the past is that it has been divorced too much from the facts of our social life. But these facts are now accumulating, becoming scientifically organized and generalized, and there is good reason for believing that by focusing such scientific conclusions upon the minds of a developing generation, we can secure an era of social progress such as the world has hitherto scarcely dreamed of. The scientific program of accumulating and rationalizing knowledge, and then of socially organizing and directing the use of such knowledge, as a basis for furthering social progress, is not a chimerical one.

But several things will have to be done by our public school system before education can become the powerful instrument of social progress which it should be. In the first place, more attention will have to be given to the finding and training of social leaders than has yet been given. Nothing great is accomplished in human society without leadership; and advances in a high civilization depend upon finding and training leaders along many lines. The higher institutions of education should be especially charged with this function. They are making a beginning, to be sure, in western civilization in finding and training leaders along a number of lines; but the general field of social leadership they are still largely neglecting. They are producing experts in law and medicine, in agriculture and engineering, but experts in dealing with the larger problems of human living together very rarely; yet these latter are the ones most needed. The superior society of the future, in other words, must be produced just as we are to produce the superior engine. It must be produced by the trained, scientific mind that knows social facts and forces so that it can map out and plan a superior social organization. The superior individual and the superior society are not antitheses, but correlatives. Only our educational system must be brought to realize that social values are not carried by individuals alone or wholly wrapped up in the concept of personality; but that they are also carried by institutional forms and inhere in the larger social life. We must pay attention to the development of the individual and his personality; but we should do so remembering that that development is largely for the sake of society, that is to say the larger life of humanity.

Another thing which will have to be done by our public school system is to effect some sort of coordination between the school and other educational institutions. In the nature of things the school can furnish only a part of the education of

the child. But it should be the center of his education and should set the standard. The home and the church are scarcely less important educational institutions, and some way should be found of coordinating them with the school. In the more specialized phases of education the work of other institutions, such as the farm and the factory, should also be coordinated with that of the school. The school, in brief, needs to come into more vital connection with all other phases of the social life.

Finally, the public school system will have to make larger provision for direct instruction regarding social matters, if it is to become an effective instrument for social progress. Social progress, after all, depends at bottom on awakening and rationalizing social consciousness. The progress of society, even more than the development of the individual, comes through the growth of self-knowledge. Accordingly, our universities should make more provision for research along social lines; and our colleges and secondary schools should give more instruction in the social sciences. We can not have intelligent social service on the part of our citizens without their possessing social knowledge; and indeed they will lack even rational motive for such service without such knowledge. Social progress, then, obviously depends upon the perfecting and diffusion of scientific knowledge of society; and this last depends largely upon our educational system.

These commonplaces of educational and social science show that the general theory of Ward that education is the proximate means of social progress is sound; and that the view of those eighteenth-century social philosophers who held that education is the method of social advance is much more nearly correct than some views which have had vogue during the last few decades. After this war, it is to be hoped that we shall take up the work of socializing our system of education in earnest, as the sure foundation upon which we can build a worthy civilization for the future. For civilization is only just beginning. The work for rational and scientifically planned social progress lies all ahead. And socialized education is the key to such progress.

THE COMPLEXITY OF THE CHEMICAL ELEMENTS¹

By Professor FREDERICK SODDY, M.A., F.R.S.

THE elements of the chemist are now known to be complex in three different senses. In the first sense the complexity is one that concerns the general nature of matter, and therefore of all the elements in common to greater or less degree. It follows from the relations between matter and electricity which have developed gradually during the past century as the result of experiments made and theories born within the four walls of this institution. Associated initially with the names of Davy and Faraday, they have only in these days come to full fruition as the result of the very brilliant elucidation of the real nature of electricity by your distinguished professor of physics, Sir Joseph Thomson. Such an advance, developing slowly and fitfully, with long intervals of apparent stagnation, needs to be reviewed from generation to generation, disentangled from the undergrowth that obscures it, and its clear conclusions driven home. This complexity of the chemical elements is a consequence of the condition that neither free electricity nor free matter can be studied alone, except in very special phenomena. Our experimental knowledge of matter in quantity is necessarily confined to the complex of matter and electricity which constitutes the material world. This applies even to the "free" elements of the chemist, which in reality are no more free than they are in their compounds. The difference is merely that, whereas in the latter the elements are combined with other elements, in the so-called free state they are combined with electricity. I shall touch but briefly on this first aspect, as in principle it is now fairly well understood. But its consistent and detailed application to the study of chemical character is still lacking.

The second sense in which the elements, or some of them at least, are known now to be complex has, in sharp contrast to the first, developed suddenly and startlingly from the recognition in radioactive changes, of different radio-elements, non-separable by chemical means, now called isotopes. The natural corollary of this is that the chemical element represents rather

¹ Lecture before the Royal Institution of Great Britain.

a type of element, the members of the type being only chemically alike. Alike they are in most of those properties which were studied prior to the last decade of last century and which are due, as we now think, to the outer shells of the atom, so alike that all the criteria, hitherto relied upon by the chemist as being the most infallible and searching, would declare them to be identical. The apparent identity goes even deeper into the region reached by X-ray spectrum analysis which fails to distinguish between them. The difference is found only in that innermost region of all, the nucleus of the atom, of which radioactive phenomena first made us aware.

But, though these phenomena pointed the way, and easily showed to be different what the chemist and spectroscopist would have decided to be identical, it did more. It showed that although the finer and newer criteria, relied upon by the chemist in his analysis of matter, must of necessity fail in these cases, being ultimately electrical in character, yet the difference should be obvious in that most studied and distinctive characteristic of all—the criterion by which Dalton first distinguished the different kinds of atoms—the atomic weight. Those who have devoted themselves to the exact determination of these weights have now confirmed the difference in two separate cases, which, in absence of what perhaps they might regard as “preconceived notions,” they were unable to discover for themselves. This is the experimental development to which I wish more especially to direct your attention. It indicates that the chemical analysis of matter is, even within its own province, superficial rather than ultimate, and that there are indefinitely more distinct elements than the ninety-two possible types of element accommodated by the present periodic system.

The third sense in which the elements are known to be complex is that which, in the form of philosophical speculations, has come down to us from the ancients, which inspired the labors of the alchemists of the Middle Ages, and which in the form of Prout's hypothesis has reappeared in scientific chemistry. It is the sense that denies to nature the right to be complex, and from the earliest times, faith outstripping knowledge, has underlain the belief that all the elements must be built up of the same primordial stuff. The facts of radioactive phenomena have shown that all the radio-elements are indeed made up of lead and helium, and this has definitely removed the question from the region of pure speculation. We know that helium is certainly a material constituent of the elements in the Proutian sense, and it would be harmless, if probably fruit-

less, to anticipate the day of fuller knowledge by atom building and unbuilding on paper. Apart altogether from this, however, the existence of isotopes, the generalization concerning the Periodic Law that has arisen from the study of radioactive change on the one hand and the spectra of X-rays on the other, and experiments on the scattering of α -particles by matter, do give us for the first time a definite conception as to what constitutes the difference between one element and another. We can say how gold would result from lead or mercury, even though the control of the processes necessary to effect the change still eludes us. The nuclear atom proposed by Sir Ernest Rutherford, even though, admittedly, it is only a general and incomplete beginning to a complete theory of atomic structure, enormously simplifies the correlation of a large number of diverse facts. This and what survives of the old electronic theory of matter, in so far as it attempted to explain the periodic law, will therefore be briefly referred to in conclusion.

THE FREE ELEMENT A COMPOUND OF MATTER AND ELECTRICITY

Although Davy and Faraday were the contemporaries of Dalton, it must be remembered that it took chemists fifty years to put the atomic theory on a definite and unassailable basis, so that neither of these investigators had the benefit of the very clear view we hold to-day. Davy was the originator of the first electrochemical theory of chemical combination, and Faraday's dictum, "the forces of chemical affinity and electricity are one and the same," it is safe to say, inspires all the modern attempts to reduce chemical character to a science in the sense of something that can be measured quantitatively, as well as expressed qualitatively. Faraday's work on the laws of electrolysis and the discovery that followed from it, when the atomic theory came to be fully developed, that all monovalent atoms or radicles carry the same charge, that divalent atoms carry twice this charge and so on, can be regarded to-day as a simple extension of the law of multiple proportions from compounds between matter and matter to compounds between matter and electricity. Long before the electric charge had been isolated, or the properties of electricity divorced from matter discovered, the same law of multiple proportions which led, without any possibility of escape, to an atomic theory of matter, led, as Helmholtz pointed out in his well-known Faraday lecture to the Chemical Society in this theater in 1881, to an atomic theory of electricity.

The work of Hittorf on the migration of ions, the bold and

upsetting conclusion of Arrhenius that in solution many of the compounds hitherto regarded as most stable exist dissociated into ions, the realization that most of the reactions that take place instantaneously, and are utilized for the identification of elements in chemical analysis, are reactions of ions rather than of the element in question, made very familiar to chemists the enormous difference between the properties of the elements in the charged and in the electrically neutral state.

More slowly appreciated, and not yet perhaps sufficiently emphasized, was the unparalleled intensity of these charges in comparison with anything that electrical science can show, which can be expressed tritely by the statement that the charge on a milligram of hydrogen ions would raise the potential of the world 100,000 volts. Or, if we consider another aspect, and calculate how many free hydrogen ions you could force into a bottle without bursting it, provided, of course, that you could do so without discharging the ions, you would find that, were the bottle of the strongest steel, the breech of a gun, for example, it would burst, by reason of the mutual repulsion of the charges, before as much was put in as would, in the form of hydrogen gas, show the spectrum of the element in a vacuum tube.

Then came the fundamental advances in our knowledge of the nature of electricity, its isolation as the electron, or atom of negative electricity, the great extension of the conception of ions to explain the conduction of electricity through gases, the theoretical reasoning, due in part to Heaviside, that the electron must possess inertia inversely proportional to the diameter of the sphere on which it is concentrated by reason of the electromagnetic principles discovered by Faraday, leading to the all-embracing monism that all mass may be of electro-magnetic origin.

This put the coping-stone to the conclusion that the elements as we apprehend them in ordinary matter are always compounds. In the "free" state they are compounds of the element in multiple atomic proportions with the electron. The ions, which are the real chemically uncombined atoms of matter, can no more exist free in quantity than can the electrons.

The compound may be individual as between the atom and the electron, or it may be statistical, affecting the total number merely of the opposite charges, and the element presumably will be an insulator or conductor of electricity accordingly. Analogously, with compounds, the former condition applies to unionized compounds such as are met with in the domain of

organic chemistry, or ionized, as in the important classes of inorganic compounds, the acids, bases and salts. Just as the chemist has long regarded the union of hydrogen and chlorine as preceded by the decomposition of the hydrogen and chlorine molecule, so he should now further regard the union itself as a decomposition of the hydrogen atom into the positive ion and the negative electron, and a combination of the latter with the chlorine atom.

One of the barriers to the proper understanding and quantitative development of chemical character from this basis is, perhaps, the conventional idea derived from electrostatics, that opposite electric charges neutralize one another. In atomic electricity or chemistry, though the equality of the opposite charges is a necessary condition for existence, there is no such thing as neutralization, or the electrically neutral state. Every atom being the seat of distinct opposite charges, intensely localized, the state of electric neutrality can apply only to a remote point outside it, remote in comparison with its own diameter. We are getting back to the conception of Berzelius, with some possibility of understanding it, that the atom of hydrogen, for example, may be strongly electro-positive, and that of chlorine strongly electro-negative, with regard to one another, and yet each may be electrically neutral in the molar sense. Some day it may be possible to map the electric field surrounding each of the ninety-two possible types of atom, over distances comparable with the atomic diameter. Then the study of chemical character would become a science in Kelvin's sense, of something that could be reduced to a number. But the mathematical conceptions and methods of attack used in electrostatics for macroscopic distances are ill-suited for the purposes of chemistry, which will have to develop methods of its own.

We have to face an apparent paradox that the greater the affinity that binds together the material and electrical constituents of the atom, the less is its combining power in the chemical sense. In other words, the chemical affinity is in inverse ratio to the affinity of matter for electrons. The helium atoms offer a very simple and instructive case. Helium is non-valent and in the zero family, possessing absolutely no power of chemical combination that can be detected. Yet we know the atom possesses two electrons, for in radioactive change it is expelled without them as the α -particle. The discharge of electricity through it and positive-ray analysis show that the electrons, or certainly one of them, are detachable by electric

agencies, although not by chemical agencies. One would expect helium to act as a diad, forming helides analogous to oxides.

Professor Armstrong for long advocated the view that these inert gases really are endowed with such strong chemical affinities that they are compounds that have never been decomposed. They certainly have such strong affinities for electrons that the atom, the complex of the $+$ ion and electrons, can not be decomposed chemically. Yet, in this case, where the affinity of the matter for the electron is at a maximum, the chemical combining power is absent.

These gases seem to furnish the nearest standard we have to electric neutrality in the atomic sense. The negative charge of the electrons exactly satisfies the positive charge of the matter, and the atomic complex is chemically, because electrically, neutral. In the case of the electro-positive elements, hydrogen and the alkali-metals, one electron more than satisfies the positive charge on the ion, and so long as the equality of opposite charges is not altered, the electron tries to get away. In the case of the electro-negative elements, such as the halogens, the negative charge, though equal presumably to the positive, is not sufficient to neutralize the atom. Hence these groups show strong mutual affinity, one having more and the other less negative electricity than would make the system atomically neutral like helium. The electron explains well the merely numerical aspect of valency. But chemical combining power itself seems to require the idea that equal and opposite charges in the atomic sense are only exactly equivalent in the case of the inert gases. None of these ideas are now new, but their consistent application to the study of chemical compounds seems curiously to hang fire, as though something were still lacking.

It is so difficult for the chemist consistently to realize that chemical affinity is due to a dissociating as well as to a combining tendency and is a differential effect. There is only one affinity, probably, and it is the same as that between oppositely charged spheres. But, atomic charges being enormous and the distances over which they operate in chemical phenomena being minute, this affinity is colossal, even in comparison with chemical standards. What the chemist recognizes as affinity is due to relatively slight differences between the magnitude of the universal tendency of the electron to combine with matter in the case of the different atoms. Over all is the necessary condition that the opposite charges should be equivalent, but this

being satisfied, the individual atoms display the tendencies inherent in their structure, some to lose, others to gain electrons, in order, as we believe from Sir Joseph Thomson's teaching, to accommodate the number of electrons in the outermost ring to some definite number. Chemical affinity needs that some shall lose as well as others gain. Chemical union is always preceded by a dissociation. The tendency to combine, only, is specific to any particular atom, but the energy and driving power of combination is the universal attraction of the + for the — change, of matter for the electron.

THE ELECTRICAL THEORY OF MATTER

Another barrier that undoubtedly exists to the better appreciation of the modern point of view, even among those most willing to learn, is the confusion that exists between the earlier and the present attempt to explain the relation between matter and electricity. We know negative electricity apart from matter as the electron. We know positive electricity apart from the electron, the hydrogen ion and the radiant helium atom or α -particle of radioactive change for example, and it *is* matter in the free or electrically uncombined condition. Indeed, if you want to find matter free and uncombined, the simple elementary particle of matter in the sense of complexity being discussed, you will go, paradoxically, to what the chemist terms a compound rather than to that which he terms the free element. If this compound is ionized completely it constitutes the nearest approach to matter in the free state. Thus all acids owe their common acidic quality to really free hydrogen, the hydrogen ion, a particle more different from the hydrogen atom than the atom is from the hydrogen molecule.

Positive electricity is thus emphatically not the mere absence of electricity, and any electrical theory of matter purporting to explain matter in terms of electricity does so by the palpable sophistry of calling two fundamentally different things by the same name. The dualism remains whether you speak of matter and electricity, or of positive and negative electricity, and the chemist would do well to stick to his conception of matter, until the physicist has got a new name for positive electricity which will not confuse it with the only kind of electricity that can exist apart from matter.

On the other hand, the theory of the electro-magnetic origin of mass or inertia is a true monism. It tries to explain consistently two things—the inertia of the electron and the inertia of matter—by the same cause. The inertia of the

former being accounted for by the well-known electro-magnetic principles of Faraday, by the assumption that the charge on the electron is concentrated into a sphere of appropriate radius; the 2,000-fold greater inertia of the hydrogen ion, for example, can be accounted for by shrinking the sphere to one two-thousandth of the electronic radius.

But the electrical dualism remains completely unexplained. Call the electron E and the hydrogen ion H . The facts are that two E 's repel one another with the same force and according to the same law as two H 's repel each other, or as an H attracts an E . These very remarkable properties of H and E are not explained by the explanation of the inertia. Are E and H made up of the same stuff or of two different stuffs? We do not know, and certainly have no good reason to assume, that matter minus its electrons is made of the same thing as the electron. We have still to reckon with two different things.

THE CHEMICAL ELEMENTS NOT NECESSARILY HOMOGENEOUS

I pass now to the second and most novel sense in which the elements, or some of them at least, are complex. In their discovery of new radioactive elements, M. and Mme. Curie used radioactivity as a method of chemical analysis precisely as Bunsen and Kirchhoff, and later Sir William Crookes, used spectrum analysis to discover caesium and rubidium, and thallium. The new method yielded at once, from uranium minerals, three new radio-elements, radium, polonium and actinium. According to the theory of Sir Ernest Rutherford and myself, these elements are intermediate members in a long sequence of changes of the parent element uranium. In a mineral the various members of the series must coexist in equilibrium, provided none succeed in escaping from the mineral, in quantities inversely proportional to their respective rates of change, or directly proportional to their periods of average life. Radium changes sufficiently slowly to accumulate in small but ponderable quantity in a uranium mineral, and so it was shown to be a new member of the alkaline-earth family of elements, with atomic weight 226.0, occupying a vacant place in the periodic table. Polonium changes 4,500 times more rapidly, and can only exist to the extent of a few hundredths of a milligram in a ton of uranium mineral. Actinium also, though its life period is still unknown, and very possibly is quite long, is scarce for another reason, that it is not in the main line of disintegration, but in a branch series which claims only a few per cent. of the uranium atoms disintegrating. In spite of this,

polonium and actinium have just as much right to be considered new elements, probably, as radium has. Polonium has great resemblance in chemical character both to bismuth and tellurium, but was separated from the first by Mme. Curie and from the second by Marckwald. In the position it occupies as the last member of the sulphur group, bismuth and tellurium are its neighbors in the periodic table. Actinium resembles the rare-earth elements, and most closely lanthanum, but an enrichment of the proportion of actinium from lanthanum has been effected by Giesel. The smallness of the quantities alone prevents their complete separation in the form of pure compounds as was done for radium.

The three gaseous members, the emanations of radium, actinium and thorium, were put in their proper place in the periodic table almost as soon as radium was, for, being chemically inert gases, their characterization was simple. They are the last members of the argon family, and the fact that there are three of about the same atomic weight was probably the first indication, although not clearly appreciated, that more than one chemical element could occupy the same place in the periodic table.

The extension of the three disintegration series proceeded apace; new members were being continually added, but no other new radio-elements—new, that is, in possessing a new chemical character—were discovered. The four longest-lived to be added, radio-lead or radium-D, as it is now more precisely termed, and ionium in the uranium series, and mesothorium-I and radiothorium in the thorium series, could not be separated from other constituents always present in the minerals, radium-D from lead, ionium and radiothorium from thorium, and mesothorium-I from radium. An appreciable proportion of the radioactivity of a uranium mineral is due to radium-D and its products, and its separation would have been a valuable technical achievement, but, though many attempts have been made, this has never been accomplished, and, we know now, probably never will be.

Seven years ago it was the general opinion in the then comparatively undeveloped knowledge of the chemistry of the radio-elements, that there was nothing especially remarkable in this. The chemist is familiar with many pairs or groups of elements, the separation of which is laborious and difficult, and the radio-chemist had not then fully appreciated the power of radioactive analysis in detecting a very slight change in the proportions of two elements, one or both of which were radioactive. The case

is not at all like that of the rare-earth group of elements, for example, in which the equivalent or atomic weight is used as a guide to the progress of the separation. Here the total difference in the equivalent of the completely separated elements is only a very small percentage of the equivalent, and the separation must already have proceeded a long way before it can be ascertained.

Human nature plays its part in scientific advances, and the chemist is human like the rest. My own views on the matter developed with some speed when, in 1910, I came across a new case of this phenomenon. Trying to find out the chemical character of mesothorium-I, which had been kept secret for technical reasons, I found it to have precisely the same chemical character as radium, a discovery which was made in the same year by Marckwald, and actually first published by him. I delayed my publication some months to complete a very careful fractional crystallization of the barium-radium-mesothorium-I chloride separated from thorianite. Although a great number of fractionations were performed, and the radium was enriched, with regard to the barium, several hundred times, the ratio between the radium and mesothorium-I was, within the very small margin of error possible in careful radioactive measurements, not affected by the process. I felt justified in concluding from this case, and its analogy with the several other similar cases then known, that radium and mesothorium-I were non-separable by chemical processes, and had a chemical character not merely like, but identical. It followed that some of the common elements might similarly be mixtures of chemically identical elements. In the cases cited, the non-separable pairs differ in atomic weight from 2 to 4 units. Hence the lack of any regular numerical relationships between the atomic weights would on this view follow naturally.² This idea was elaborated in the Chemical Society's Annual Report on Radioactivity for 1910, in the concluding section summing up the position at that time. This was, I think, the beginning of the conception of different elements identical chemically, which later came to be termed "isotopes," though it is sometimes attributed to K. Fajans, whose valuable contributions to radioactivity had not at that date commenced, and whose first contribution to this subject did not appear till 1913.

In the six or seven years that have elapsed the view has received complete vindication. Really, three distinct lines of advance converged to a common conclusion, and, so far as is

² Trans. Chem. Soc., 1911, XCIX., 72.

possible, these may be disentangled. First, there has been the exact chemical characterization from the new point of view of every one of the members of the three disintegration series, with lives over one minute. Secondly, came the sweeping generalizations in the interpretation of the periodic law. Lastly, there has been the first beginnings of our experimental knowledge of atomic structure, which got beyond the electronic constituents and at the material atom itself.

In pursuance of the first, Alexander Fleck, at my request, commenced a careful systematic study of the chemical character of all the radio-elements known of which our knowledge was lacking or imperfect, to see which were and which were not separable from known chemical elements. Seldom can the results of so much long and laborious chemical work be expressed in so few words. Every one, that it was possible to examine, was found to be chemically identical either with some common element or with another of the new radio-elements. Of the more important characterizations, mesothorium-II was found to be non-separable from actinium, radium-A from polonium, the three B-members and radium-D from lead, the three C-members and radium-E from bismuth, actinium-D and thorium-D from thallium. These results naturally took some time to complete, and became known fairly widely to others working in the subject before they were published, through A. S. Russell, an old student, who was then carrying on his investigations in radioactivity in Manchester. Their interpretation constitutes the second line of advance.

Before that is considered, it may first be said that every case of chemical non-separability put forward has stood the test of time, and all the many skilled workers who have pitted their chemical skill against Nature in this quest have merely confirmed it. The evidence at the present day is too numerous and detailed to recount. It comes from sources, such as in the technical extraction of mesothorium from monazite, where one process is repeated a nearly endless number of times; from trials of a very great variety of methods, as, for example, in the investigations on radium-D and lead by Paneth and von Hevesy; it is drawn from totally new methods, as in the beautiful proof by the same authors of the electro-chemical identity of these two isotopes; it is at the basis of the use of radioactive elements as indicators for studying the properties of a common element, isotopic with it, at concentrations too feeble to be otherwise dealt with, and from large numbers of isolated observations, as well as prolonged systematic researches. One

of the finest examples of the latter kind of work, the Austrian researches on ionium, will be dealt with later. The most recent, which appeared last month, is by T. W. Richards and N. F. Hall, who subjected lead from Australian carnotite, containing therefore radium-D, to over a thousand fractional crystallizations in the form of chloride, without appreciably altering the atomic weight or the β -activity. So that it may be safely stated that no one who has ever really tested this conclusion now doubts it, and after all they alone have a right to an opinion.

This statement of the non-separability by chemical methods of pairs or groups of elements suffers perhaps from being in a negative form. It looks too much like a mere negative result, a failure, but in reality it is one of the most sweeping positive generalizations that could be made. Ionium we say is non-separable from thorium, but every chemist knows thorium is readily separated from every other known element. Hence, one now knows every detail of the chemistry of the vast majority of these new radio-elements by proxy, even when their life is to be measured in minutes or seconds, as completely as if they were obtainable, like thorium is, by the ton. The difference it makes can only be appreciated by those who have lived through earlier days, when, in some cases, dealing with the separation of radio-constituents from complex minerals, after every chemical separation one took the separated parts to the electroscope to find out where the desired constituent was.

As the evidence accumulated that we had to deal here with something new and fundamental, the question naturally arose whether the spectrum of isotopes would be the same. The spectrum is known, like the chemical character, to be an electronic rather than mass phenomenon, and it was to be expected that the identity should extend to the spectrum. The question has been tested very thoroughly by A. S. Russell and R. Rossi in this country, and by the Austrian workers at the Radium Institut of Vienna, for ionium and thorium, and by various workers for the various isotopes of lead. No certain difference has been found, and it may be concluded that the spectra of isotopes are identical. This identity probably extends to the X-ray spectra, Rutherford and Andrada having shown that the spectrum of the γ -rays of radium-B is identical with the X-ray spectrum of its isotope, lead.

(To be continued)

THE FIRST HUNDRED YEARS
OF THE
NEW YORK ACADEMY OF SCIENCES

By Dr. JOHN HENDLEY BARNHART

NEW YORK BOTANICAL GARDEN

THE College of Physicians and Surgeons was the one institution in the city of New York, a hundred years ago, which afforded a stimulus to the study of the natural sciences. This was due to the inspiring influence of a single member of the college faculty, Professor Samuel Latham Mitchill, whose name is not as familiar as it should be to the scientists of to-day. In 1816 he was fifty-two years old. He had studied both medicine and law; had served two terms in the legislature of New York, four terms in Congress, and one in the Senate of the United States. For eight years he had been professor of natural history in the medical college; his personal magnetism had attracted many of the students, and he had awakened in them a more than passing interest in the subjects taught by him. There can be no doubt that it was from Dr. Mitchill that the impetus came for the establishment of a scientific society among the young men who gathered about him, and for this if for nothing else he should be held in loving remembrance on this centennial occasion.

It was in the hall of the College of Physicians and Surgeons, in Barclay Street, on the twenty-ninth day of January, 1817, that a few kindred spirits gathered to consider the establishment of an institution devoted to the study of natural history. Dr. Mitchill occupied the chair. Seven more preliminary meetings were held at the college within a month, and finally, all the arrangements being completed, and a constitution adopted and engrossed, the Lyceum of Natural History held its first formal meeting in the evening of the twenty-fourth day of February, at Harmony Hall, a public house on the southeast corner of Duane and William Streets. The first twenty-one members signed the constitution at this time, and the first officers were elected.

Dr. Mitchill was the president; his nephew, Dr. Caspar Wistar Eddy, was the first vice-president; the second vice-president was Rev. Frederick Christian Schaeffer, the young

pastor of Christ Lutheran Church; Dr. John Wakefield Francis, one of Dr. Mitchill's younger colleagues on the faculty of the medical college, was corresponding secretary; the recording secretary was John Brodhead Beck, then a student of medicine; and the treasurer was Dr. Benjamin P. Kissam, who had received his medical degree the preceding year. It is noteworthy that, of the twenty-one signers of the constitution at this meeting, a majority were students, graduates or members of the faculty of the College of Physicians and Surgeons, and as far as known none but the president was more than twenty-seven years old. Among those added during the next three months, and counted as "original members," were several older men, and some who were in no way connected with the medical college, but of these few were ever active in the affairs of the Lyceum.

For nearly fifteen years, from April, 1817, to September, 1831, the Lyceum enjoyed the hospitality of the Common Council of the city, sharing with other societies, rent free, the use of the "New York Institution," popularly known as the "Old Almshouse," in City Hall Park. Here the Lyceum had rooms for its meetings, and for the preservation and display of its collections; these grew apace, not only by gifts, but by the incorporation of material collected specifically for the "cabinet" by Lyceum members. Dr. Mitchill wrote:

The members called it the Lyceum, in remembrance of the school founded by that sublime genius, Aristotle, at Athens. Disciples of the "mighty Stagirite," they determined, after his example, to be Peripatetics, and to explore and expound the arcana of nature as they walked.

During the first year of the society, 1817, we have mention of collecting trips by Mitchill, Townsend, Torrey, Rafinesque, and Knevels. Within ten years the cabinet of the Lyceum comprised one of the most extensive collections of natural objects in America, excelling all others in its series of minerals, fossils, reptiles, fishes and echinoderms. It is evident that one of the chief purposes of the society from its establishment was the formation of such a museum, and its success was phenomenal.

Soon after the establishment of the Lyceum, the formation of a library was commenced, but this consisted largely of books loaned by members and subsequently withdrawn, so that after an interval of seven years the number of books actually owned by the society was less than two hundred. An old organization known as the United States Military and Philosophical Society, however, having become extinct, with about \$2,500 in its treasury, the surviving members transferred this sum to the Lyceum

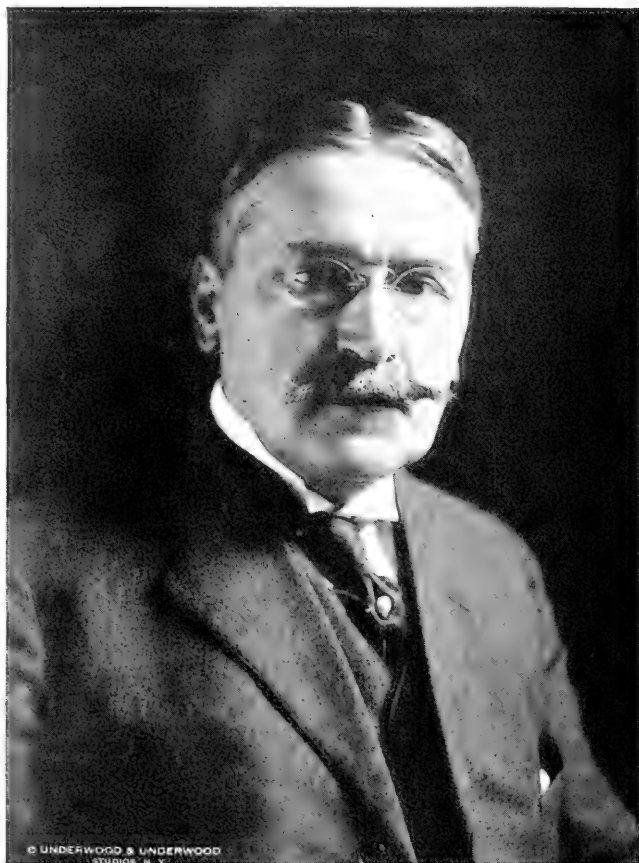


SAMUEL LATHAM MITCHELL.

President of the Lyceum of Natural History, 1817 to 1823.

for use as a library fund. This happened in 1825, and the library then began to grow rapidly and steadily. There are various statistical reports and catalogues recording the number of books at different dates, but it is impossible to use these for comparison, chiefly because of failure to distinguish clearly between the number of volumes and the number of titles.

The first publication of the Lyceum was undoubtedly the printed Constitution, laid on the table at the meeting of May 19, 1817. Technical scientific publication commenced with the issue of the first number of the *Annals*, in 1823. Two volumes had been completed five years later; these initiated the long series of *Annals*, *Proceedings*, *Transactions*, and *Memoirs*, that have spread the fame of the earlier Lyceum and later Academy throughout the world of science.

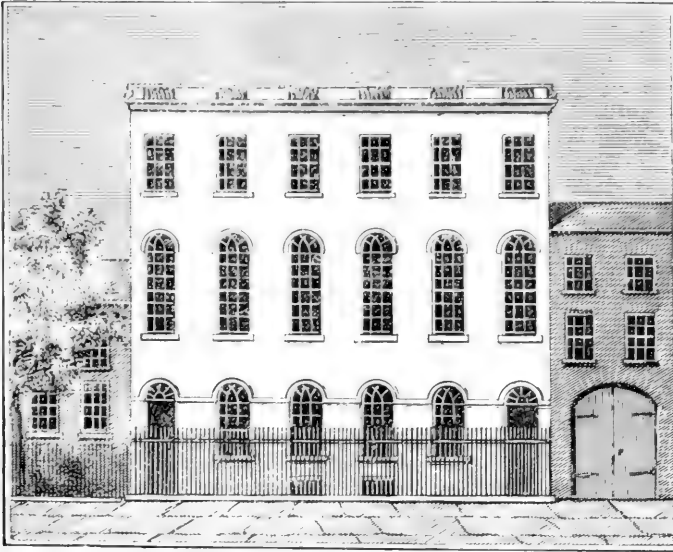


MICHAEL IDVORSKY PUPIN

President of the New York Academy of Sciences, 1916 to 1917.

In 1829 the members of the Lyceum learned that they might at any time be required to vacate the four rooms in the New York Institution occupied by them for their meetings, library, and collections, and they began at once to look about for new quarters. A building-fund was inaugurated, but the project had not even reached the stage of selection of a building-site when removal became imperative. The library and collections were temporarily deposited in other rooms in the same building during the winter of 1830-31; the following summer they were removed to new rooms in the New York Dispensary, on the corner of White and Center Streets, and in these rooms the Lyceum met for the first time September 4, 1831.

The Dispensary remained the home of the Lyceum for nearly five years. Meanwhile, the building project was being pushed

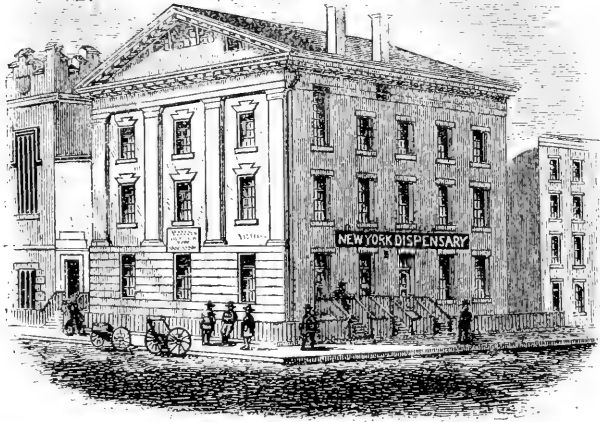


COLLEGE OF PHYSICIANS AND SURGEONS, BARCLAY STREET. Where the Lyceum of Natural History was Organized, 1817.

with more energy than caution. In January, 1835, two lots were purchased at 561-565 Broadway, south of Prince Street; construction was commenced in May. A year later, May 9, 1836, the society held its first meeting in its new building.

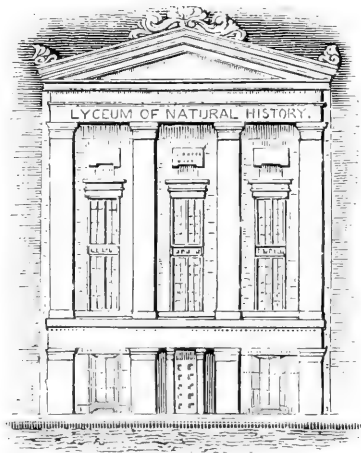


NEW YORK INSTITUTION, *The "Old Almshouse."* Western End, Facing Broadway. Home of the Lyceum from 1817 to 1831.



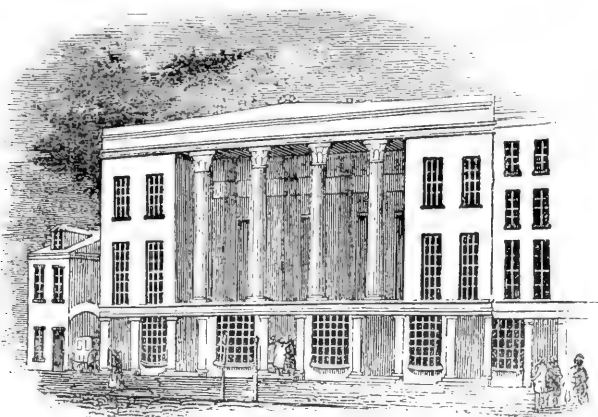
NEW YORK DISPENSARY, WHITE AND CENTRE STREETS. Home of the Lyceum from 1831 to 1836.

There was now ample room for the proper accommodation of the collections and library, and there were stores on the street level and rooms on the upper floors to contribute an income. About fifteen thousand dollars in cash had been invested in the land and building; but this was in a period of financial inflation, and the three mortgages on the property totalled thirty-five thousand dollars. During the years of depression that followed, the financial troubles of the Lyceum went from bad to worse, until finally, in February, 1844, the property was sold at



THE LYCEUM BUILDING, No. 563 BROADWAY. Erected 1835-6; Lost by Foreclosure of Mortgage, 1844.

auction, under legal proceedings, for thirty-seven thousand dollars, barely enough to cover the amount of the mortgages and the unpaid interest thereon. "And the Lyceum found itself out of debt and out of a home, with a valuable library and large collections, and no place to put them." For a year, the collections were stored and the library deposited in the buildings of New York University, while the meetings were held in the home of the president, Major Joseph Delafield, at 104 Franklin Street.



STUYVESANT INSTITUTE, UNIVERSITY MEDICAL COLLEGE. Home of the Lyceum from 1844 to 1851.

After a period of much uncertainty, arrangements were finally completed for rooms with the University Medical College, in Stuyvesant Institute, 659 Broadway, opposite Bond Street. Here the library was satisfactorily accommodated, and a considerable part of the collections could be displayed, and here the Lyceum met for the first time April 7, 1845. In 1851, the medical college sold the building and erected a new one on Fourteenth Street, on the site since long occupied by Tammany Hall. The Lyceum accepted the offer of a meeting-room in the new building, but the collections, with minor exceptions, had to be boxed and stored in the cellar, while the library was deposited temporarily with the Mercantile Library Association.

For fifteen years the Lyceum held its meetings in the Fourteenth Street building, until, on the night of May 21, 1866, this was totally destroyed by fire. The society which had lost its building in 1844 was now without collections; after half a century of enthusiastic work and sacrifice, it was without material possessions other than its library. Well may the members have been discouraged, but they were undismayed; their work went

on. For a year the meetings were held in the rooms of the Geographical Society, in Clinton Hall, the same building in which the Lyceum's library had been housed for years.



UNIVERSITY MEDICAL COLLEGE, FOURTEENTH STREET. Erected 1851; Destroyed by Fire, 1866. Home of the Lyceum throughout this Period.

The loss of the collections, as viewed with the perspective of later years, was a blessing in disguise. It relieved the Lyceum of a heavy and ever-increasing burden of responsibility, and paved the way for the establishment of a great independently endowed museum. Such an institution was incorporated three years later, became an actuality within a few more years, and to-day is the scientific center of our great metropolis.

In 1867 the Lyceum removed to Mott Memorial Hall, 64 Madison Avenue; here its library was also installed, and both society and library remained until May, 1878. The semi-centennial of the organization of the Lyceum, in 1867, was allowed to pass by without any formal celebration; but early the following year, April 29, 1868, a public meeting was held in the Great Hall of Cooper Union, in honor of the fiftieth anniversary of the acceptance of the Charter. The historical sketch presented at that time by Professor John Torrey, the only surviving original member, was not preserved.

While the society was located at Mott Memorial Hall, under the presidency of Professor John Strong Newberry, a strong movement sprang up for a change of name. Of course there were many conservative members, particularly those who did not wish to abandon the name with which years of association had linked their affections; but it was urged that the name "Lyceum" had been put to such varied uses that it had lost any appropriateness it might have possessed when originally chosen, that "Natural History" no longer indicated the actual scope of the society's activities, that there was no other organization in New York City devoted to science in general and to science alone, and that the name "The Lyceum of Natural History in the City of New York" was unnecessarily cumbersome. After much discussion, the alteration of the name was approved by the required three-fourths vote; the Supreme Court confirmed the change, and it was accepted by the society February 2, 1876, when the corporate name became The New York Academy of Sciences. At the same time a special class of membership was introduced, called Fellows, "chosen from among the Resident Members in virtue of scientific attainments or services," and most of the detailed routine business of the society was delegated to a central committee called the Council.



AMERICAN MUSEUM OF NATURAL HISTORY. Present Home of the New York Academy of Sciences.

In May, 1878, the Academy deposited its library with the American Museum of Natural History, and changed its meeting-place to the building of the New York Academy of Medicine, then in West Thirty-first Street. Most of the active members of the Academy of Sciences, however, were connected in some way with Columbia College, and the following decade witnessed an increasingly close relationship between the two institutions. Beginning with October, 1883, the meetings of the Academy were held in Hamilton Hall, and three years later the Academy's library was removed from the Museum of Natural History to the Herbarium room in the college library building.

This arrangement continued until Columbia University removed to its present location in 1897.

During the earlier years at Columbia, the Academy held the even tenor of its way, maintaining its dignified position but failing to keep abreast of the rapid development of science in the city. A history of the Academy, by the recording secretary, Mr. H. L. Fairchild, was read in abstract at the meeting of May 10, 1886, and published in full the following May. This handsome volume was not very conveniently arranged for ready reference, and is somewhat unbalanced in the emphasis placed upon the various activities of the society; but it is an invaluable storehouse of reliable information concerning the sixty years of the Lyceum and the first ten of the Academy. One fact, brought out by the inscription on the title-page and the explanation in the preface, is by no means creditable to the Academy, and emphasizes its lack of enterprise at this particular time: the author, after long and faithful labor in the preparation of the manuscript, was permitted to publish the volume at his own expense.

Just how much influence the appearance of this history may have had upon the subsequent development of the Academy is uncertain. It did not call direct attention to the almost moribund condition of the organization, but it did show clearly that the Academy ought to be the leading factor in the scientific life of New York. Such was the wish of those who guided the destinies of the Academy, and they soon began to work diligently with this in view. During the few following years the active membership of the Academy gradually but slowly decreased; this limited the available income, but at the same time resulted in a more compact working body, so that the small membership should not be regarded as a true index to the efficiency of the organization.

The year 1891 witnessed a great forward movement affecting the scientific life of New York. From time to time increasing specialization had resulted in the formation of a number of scientific societies in the city, wholly independent and unrelated except through more or less overlapping of their membership. Organic union of these diverse elements was at no time practicable, yet the desirability of cooperation was self-evident. The first formal suggestion of a plan for such cooperation appears in a communication presented by Dr. N. L. Britton at a meeting of the Council of the Academy held in Room 22, Hamilton Hall, on the afternoon of December 22, 1890. It was a special meeting, called to act upon a revision of the by-

laws; but that revision proved of far less importance than the other matter then discussed. Dr. Britton's communication very concisely outlined the need for concerted action, suggested a method for its accomplishment, and enumerated some of the ways in which the proposed alliance could be of practical value. The plan was referred to a committee, approved, submitted to other scientific societies of the city, and ultimately adopted in agreement with even the minor details of the original communication; and before the close of the summer vacation season of 1891 the Scientific Alliance of New York was fully organized and had entered upon its work. For sixteen years the Alliance was a powerful adjunct of local scientific progress, and paved the way for the Greater Academy of to-day. It issued an annual directory listing the members, and a monthly bulletin announcing the meetings, of all of the component societies. It held two public joint meetings, and in many ways helped to mutualize scientific activities and to bring science prominently before the public. The success of the Alliance was due in large measure to Charles Finney Cox, its first and only president.

One of the primary objects of the Scientific Alliance, the erection of a great building which should serve as a home for all of the societies, and as a scientific center for the city, was never realized. It may yet come; but present opinion seems to favor the strengthening of existing institutions rather than the establishment of new ones. In fact, this sentiment no doubt encouraged the final dissolution of the Alliance, and the adoption of the new plan which grouped the younger organizations of a more specialized nature about the old historic Academy as affiliated societies. The new idea was first promulgated by Mr. William Dutcher, one of the delegates of the Linnæan Society of New York, at the meeting of the Council of the Scientific Alliance held at the Museum of Natural History, January 24, 1906; it met with instant approval, and forthwith was referred to the various societies for action. This was favorable in every case, and the final meeting of the Council of the Alliance was held April 18, 1907; the corporation was then consolidated with that of the New York Academy of Sciences, and the treasurer was instructed to turn over to the Academy all funds of the Alliance.

During the sixteen years of existence of the Scientific Alliance, the work of the Academy had been greatly stimulated. In 1893 there was unveiled in Trinity Cemetery a monument to Audubon, erected by popular subscription through the efforts and under the direction of a committee of the Academy ap-

pointed about five years before. A series of annual receptions and exhibitions to illustrate the recent progress of science was inaugurated in 1894, and repeated in the five succeeding years; these did much to direct the attention of the public both to scientific progress and to the work of the Academy. The organization of sections within the Academy, attempted more or less sporadically in former years, was developed more successfully than ever before.

In 1897, during the summer, Columbia University moved from its old location at Madison Avenue and Forty-ninth Street, to the new site on Morningside Heights. The following winter the Academy held its meetings at Mott Memorial Library, 64 Madison Avenue, while the library remained, practically inaccessible, in the old library building of the University on Forty-ninth Street. The University authorities, utterly regardless of their own interests, refused to allow space in their great new library building for the books of the Academy; they did, however, grudgingly consent to the use of a small room, no. 507, in Schermerhorn Hall. An agreement to this effect was signed in February, 1898; the books, however, were not removed to Schermerhorn Hall until much later in the year, and were then stored in the basement until the following summer. Never, during the four years that the library remained at Columbia after its removal to the new site, was it properly accommodated or reasonably accessible.

For the three seasons of 1898-1901, the Academy held its meetings in the rooms of the American Society of Mechanical Engineers, at 12 West 31st Street; then for one season in the assembly room of the Chemists Club, at 108 West 55th Street. Finally, fifteen years ago, in 1902, the Academy accepted an invitation from the American Museum of Natural History to make this building its permanent meeting-place. In March, 1903, the library of the Academy was brought here to the Museum, where it is properly appreciated, is faithfully and efficiently cared for, and may readily be consulted. In 1904 an office for the use of the Recording Secretary of the Academy was established here, and since that time all of the interests and activities of the Academy have centered in this building.

In 1906, as already mentioned, a proposal came from the Scientific Alliance that the other members of the Alliance should become affiliated with the Academy. This plan was approved by all of the societies concerned; the necessary amendments to the constitution and by-laws were adopted November 5, and the Alliance was wholly merged into the Academy within

the following six months. The past ten years have abundantly confirmed the wisdom of this act. The Academy and its affiliated societies, now seven in number, have enjoyed unprecedented prosperity, and have extended their activities in various directions. Perhaps the most noteworthy events of this decade have been the public celebrations of the bicentenary of the birth of Linnæus and the centenary of the birth of Darwin; the inauguration of a natural history survey of Porto Rico, in cooperation with the government of that island; and the attempt now being made to provide the Academy with adequate endowment.

The effort to condense the history of a hundred years into a brief address has compelled the selection of merely a few of the salient points; no mention has been made even of the names of many who have devoted years of service to the welfare of the Academy. There has been no lack of loyalty; few have ever resigned merely owing to loss of interest. We have now in the Academy fifty whose membership has extended over a quarter of the century; fourteen of these were members in the days of the Lyceum, before the name was altered forty-one years ago, and four have been associated with our history throughout half of its hundred years. The association is continuous, while members come and go, yet upon the exertions of individuals depends the success of the organization. May we of to-day and our successors of the coming years derive inspiration from the honorable record of the past, and emulate the devotion of our predecessors, which we surely never can excel!

THE PROGRESS OF SCIENCE

WORK OF THE NATIONAL RESEARCH COUNCIL

UPON recommendation of the National Research Council Dr. Augustus Trowbridge, of Princeton University, and Professor Theodore Lyman, of Harvard University, have received commissions in the Signal Corps, U. S. A., for work in sound ranging. They have sailed for France to investigate conditions at the front in this subject. The sound ranging service which will be developed under their direction will utilize in the near future more than fifty men. Captain Horatio B. Williams is in charge of the development work in this country during Major Trowbridge's absence.

A meteorological service has been organized under the Signal Corps, U. S. A., in which about one hundred physicists and engineers will be engaged in aerological observational work under the direction of Dr. William H. Blair, of the U. S. Weather Bureau, who has received a commission of major and has sailed for France to investigate conditions abroad. Forecasting work for the American Expeditionary Force in France will be in charge of Mr. E. H. Bowie, of the U. S. Weather Bureau, who has likewise received a commission of major in the Signal Corps and is already on his way to France. Major Bowie will be assisted by Mr. R. Hanson Weightman, of the U. S. Weather Bureau, who has received a commission as lieutenant in the Signal Corps.

Professor Charles E. Mendenhall, of the University of Wisconsin, has received a commission of major in the Signal Corps, U. S. A., and has been placed in charge of the devel-

opment of aeronautical instruments.

All the work of these services, sound-ranging, meteorology and aeronautical instruments, is included within the scope of the Science and Research Division of the Signal Corps, which in accordance with a recent order of the chief signal officer has been established and placed under the direction of the National Research Council, of which Major R. A. Millikan is the executive officer. The functions of this division of the Signal Corps are twofold, namely: (1) to furnish personnel of the research sort to the other divisions when the situation warrants the assignment of men of this type to these divisions, and (2) to have a personnel of its own which maintains intimate contact with all research and development work in other divisions, and distributes research problems to university, industrial and governmental research laboratories with which it is associated. Similar, though in some cases less formal, relations have been established with other technical bureaus of the War and Navy Departments.

Upon request of the French High Commission a number of American physicists and chemists are being sent to France to assist in various war problems in which technically trained men are needed. Except in certain cases, the Interministerial Commission in Paris will assign them to work in university laboratories and in technical services of the government. Upon recommendation of the National Research Council the following men are receiving commissions in this connection and a number of them have already sailed for France:

Professor R. W. Wood, of Johns Hopkins University, major in the U. S. Signal Corps.

Messrs. Roy W. Chestnut, Leonard Loeb and Samuel Sewall, lieutenants in the U. S. Signal Corps.

Professor Edward Bartow, of the University of Illinois, major, and Professor Reston Stevenson, of the College of the City of New York, captain, in the U. S. Sanitary Corps.

Messrs. Ralph L. Brown, of the University of Chicago, George Scatchard, of Columbia University, and Kirke W. Cushing, of Western Reserve University, lieutenants in the U. S. Sanitary Corps.

FOREST BATTALIONS FOR SERVICE IN FRANCE

THE formation of a second "Forest" regiment comprising ten battalions and composed of lumbermen and woodworkers, who will go to France and get out of the forests materials for the use of the American, French and British armies, has been authorized by the War Department.

Two battalions are to be raised at once with the active aid of the Forest Service of the Department of Agriculture. It is expected that the remaining eight battalions will be called for in a short time. Nine "service" battalions, made up of laborers who will be used in connection with the Forest regiment, have also been authorized and two battalions have been ordered raised at once.

In order to provide for future contingencies it has been decided to commission at the present time enough officers for other battalions yet to be raised. Those men not needed now will be placed on the reserve, and will be called as the other units are formed. According to the present plan, fifty per cent. of the officers will be sawmill and logging operators, twenty-five per cent. will be technical foresters, and

twenty-five per cent. will be men with military training who will be selected in the immediate future. The minimum age limit for commissioned officers has been set at thirty-one.

A considerable number of captains and lieutenants are to be selected in the immediate future. The minimum age limit for commissioned officers has been set at thirty-one.

A first regiment of woodsmen numbering about 1,200 men and designated as the Tenth Engineers (Forest) has already been recruited and assembled and is now being trained at American University, D. C. This regiment was raised at the request of the British government to undertake the production in France of crossties, bridge, trench and construction timbers, mine props, lumber, and other forms of wood required in connection with its military operations. The landing of the American expeditionary forces has made necessary similar provision for their needs, while the French military authorities have indicated that some of the work incidental to their operations might be taken over by woodsmen from this country. Decision to raise the new and much larger force has followed a study of the field of possible usefulness to the Allied cause, made by American foresters attached to General Pershing's staff.

Each of the ten battalions of the second regiment will comprise three companies of 250 men each, and will be under the command of its own major. The regiment will be made up of volunteers. Applicants must be white and between the ages of eighteen and forty.

Skilled lumberjacks, portable mill operators, tie cutters, logging teamsters, camp cooks, millwrights and charcoal burners are among the classes of men desired. For the "service" battalions both negro and white laborers will be enlisted.

PHYSIOLOGISTS AND BIO-CHEMISTS IN THE NATIONAL SERVICE

THE Surgeon General of the army is organizing a Food Division of his office, the object of which is to safeguard the nutritional interest, of the army by means of competent inspection of food from the standpoint of nutritive value, the supervision of mess conditions, including the economical utilization of food, and a study of the suitability of the army ration for troops in the camp and in the field. Well-trained physiologists and biochemists are needed to direct this work. These men are being commissioned, according to age and experience, as first lieutenants and captains in the Sanitary Corps, Medical Department; or, if they have medical degrees, in the Medical Reserve Corps.

It is probable there will be as many commissioned officers as there are camps and cantonments. Nutritional surveys will be conducted at the camps by surveying parties composed of these commissioned officers, and of drafted men, who have had scientific training, acting as assistants and clerks. It is estimated that such a survey can be completed in from ten days to two weeks for each camp.

It is hoped by means of these surveying parties also to instruct the company mess sergeants and company cooks in improved methods of selecting and preparing the foods. A school for the finished training of the scientists employed in this work is now being organized. The organization of the army, the army methods of handling and cooking foods, the latest methods of food examination and analysis, the conduct of the food survey and kindred topics will be covered by competent instructors from various departments of the army and other departments of the national government.

The facilities of the Bureau of

Chemistry, including its analytical laboratories scattered over the country, have been placed at the disposal of the Food Division for this work. Analyses of the garbage will be made and of all foods whose composition is not already known, and the actual distribution of nutrients and of total calories consumed by the men will be computed. Any alteration of the army ration in the future will be based only upon the facts as thus gathered. There is every promise that this service will prove to be of strategic importance in the control of the health and welfare of the troops from the place of their mobilization to the battle front.

THE PSYCHOLOGICAL EXAMINATION OF RECRUITS

AS was announced in *SCIENCE* at the time, a committee on psychology has been organized, with the approval of the council of the American Psychological Association, by the National Research Council. This committee consists of J. McKeen Cattell, G. Stanley Hall and E. L. Thorndike, from the National Academy of Sciences; Raymond Dodge, S. I. Franz and G. M. Whipple, from the American Psychological Association, and C. E. Seashore, J. B. Watson and R. M. Yerkes, from the American Association for the Advancement of Science. Dr. Yerkes, this year president of the American Psychological Association, lately professor of comparative psychology at Harvard University and recently elected head of the department of psychology at the University of Minnesota, is chairman of the committee, and has been made a major in the Sanitary Corps of the Army in charge of the Section of Psychology, which has been established in the office of the Surgeon General.

A number of committees were organized and are now at work on different problems connected with the conduct of the war and national effi-

ciency, partly under the auspices of the office of the Surgeon General and partly in the office of the Adjutant General. Information concerning the work of the committee on the psychological examination of recruits has been communicated to the press.

The members of that committee are R. M. Yerkes, W. V. Bingham, professor of psychology, Carnegie Institute of Technology, Pittsburgh; H. H. Goddard, director of research, the Training School, Vineland, N. J.; T. H. Haines, professor of medicine, Ohio State University; L. M. Terman, professor of educational psychology, Stanford University; F. L. Wells, psychopathologist, McLean Hospital, Waverley, Mass.; and G. M. Whipple, professor of educational psychology, University of Illinois. This committee met continuously for two weeks planning methods and tests. The seven men then separated, went to various parts of the country and applied the methods in actual practise. After making about 500 examinations they gathered again for two weeks and worked over the methods.

Six weeks after the first gathering of these psychologists, their test sheets, report blanks, etc., were ready for the printer. Arrangements were made for a trial of the method under working conditions with large numbers of men. About 4,000 men in regular organization camps, officers' training camps and naval stations, were examined, and special attention was given to correlating the ratings from the psychological examinations with the ratings prepared by the usual army methods.

The results of these thousands of examinations were sent to Columbia University, where, under the direction of Professor Thorndike and with the cooperation of Professor Cattell, Professor Woodworth and other members of the department of

psychology, ten assistants and computers worked a month assembling and analyzing the statistical results. Again the seven psychologists went over their methods in the light of these 4,000 examinations to make further improvements.

The psychological examinations are now in progress in four of the national army cantonments: Camp Devens, at Ayer, Mass.; Camp Dix, at Wrightstown, N. J.; Camp Lee, at Petersburg, Va.; and Camp Taylor, at Louisville, Ky. There are about 160,000 men to be examined in these cantonments, and each will receive an intelligence rating as a result of the psychological examination.

The work is undertaken, first, to supplement the medical examination and second, to give line officers estimates of the mental ability and special aptitudes of their men. Reports of the psychological examinations will be made to the chief surgeon of the camp or the psychiatric officer in order that those mentally incompetent may be considered for discharge, and to the regimental and company officers in order that they may use this additional information concerning their men for the improvement of the service.

OCCUPATIONAL CENSUS OF THE ARMY

THERE is now being made under the direction of the Adjutant General a comprehensive occupational and educational census of the men of the National Army. The object is to carry the selective service law to its logical conclusion and to increase the efficiency of the army by putting the right man in the right place.

With this in view, a personnel organization has been established in each of the 16 cantonments. The previous occupation, education and preference for service of every man are recorded on individual cards,

which are then filed and analyzed at the divisional personnel office in each cantonment. An analysis as to the entire 687,000 men of the first increment can readily be made from these records.

In this work the War Department is having the assistance of a body of civilian experts organized under the name "Committee on classification of personnel in the Army" and including a number of professional employment managers loaned to the government by large industrial and business concerns. The data collected will be used within the divisional organizations to assist division commanders in making the best possible assignment of their men. It will also be of importance in locating men fitted for special branches of the service, such as Aviation, the Ordnance Corps, etc., for which it may be necessary to assign men from the cantonments.

It must not be assumed that men can continue their old occupations in the army. The function of an army is to fight and most of the men, irrespective of previous occupations, will be in the infantry and artillery. Nevertheless, the specialization of modern war requires large numbers of skilled men adapted for technical units and special branches of the service. The locating and placing of such men to the best advantage is of vital importance.

SCIENTIFIC ITEMS

WE record with regret the death of Charles Lee Crandall, emeritus professor of railway engineering and geodesy in Cornell University, and of Lewis Atterbury Stimson, professor of surgery in Cornell Medical College.

THE Surgeon General of the army, Major General William C. Gorgas, has established a board to collect material for the medical and surgical history of American participa-

tion in the European War. This board is composed of Colonel C. C. McCulloch, librarian of the Army Medical Library; Major F. H. Garrison, assistant librarian in direct charge of work on the history, and Captain John S. Fulton, secretary of the Maryland State Board of Health, who will have charge of the statistical work.

GOVERNOR JAMES E. FERGUSON, of Texas, has been impeached by the legislature. The charges against him were financial irregularities and improper interference with the board of regents of the state university. The bill providing for the financial support of the university for the next biennium, which was vetoed by Governor Ferguson, has been re-passed by the legislature and signed by the acting governor. The professors who were dismissed at the instigation of Governor Ferguson have been reinstated.

DR. JOHN R. MURLIN, for eight years assistant professor of physiology in the medical school of Cornell University, has been appointed director of the new department of vital economics at the University of Rochester. This department is being organized from funds made available by the will of Lewis P. Ross, whose will gave to the university the residuary estate of more than \$800,000, the income only to be used "to the end that human life may be prolonged with increased health and happiness." The trustees were instructed to expend that income for two purposes—to contribute toward the support, improvement, and extension of the department of household economics of the Mechanics' Institute of Rochester, and to establish in the university a department of vital economics. Dr. Murlin is now a major in the Sanitary Corps of the national army, and head of the food division in the surgeon general's office.

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A PHOTOGRAPHIC RESEARCH LABORATORY¹

By DR. C. E. KENNETH MEES

RESEARCH LABORATORY, EASTMAN KODAK CO., ROCHESTER, PA.

THE research laboratory of the Eastman Kodak Company was established in 1912 to study the problems involved in the production and use of photographic materials.

Photographic research occupies a somewhat unique position in the field of applied science both because photography is so much used in other scientific work that interest in it is very widespread and because the methods of photographic research are so different from those of all other branches of scientific work that it is rare for the professional scientific man to understand them.

Very little work on the theory of photography has been done in the universities and there are perhaps three reasons for this: In the first place, information with regard to the theory of photography is not easy to obtain; there are few books on the subject and these deal generally with only a limited part of the field, and the original papers to which recourse must be had for information are scattered through a wide range of photographic and other journals. In the second place, work on the theory of photography necessarily involves work with photographic materials, and these materials are now made entirely by manufacturing companies, the methods of manufacture not being disclosed, so that the actual nature of the photographic materials themselves is but little understood by the user of them. In the third place, the apparatus required for photographic research is very specialized and somewhat expensive.

Our knowledge of photographic theory we owe chiefly to enthusiastic amateur photographers, supplemented in recent

¹ Being a paper read before the American Physical Society at the Rochester meeting.

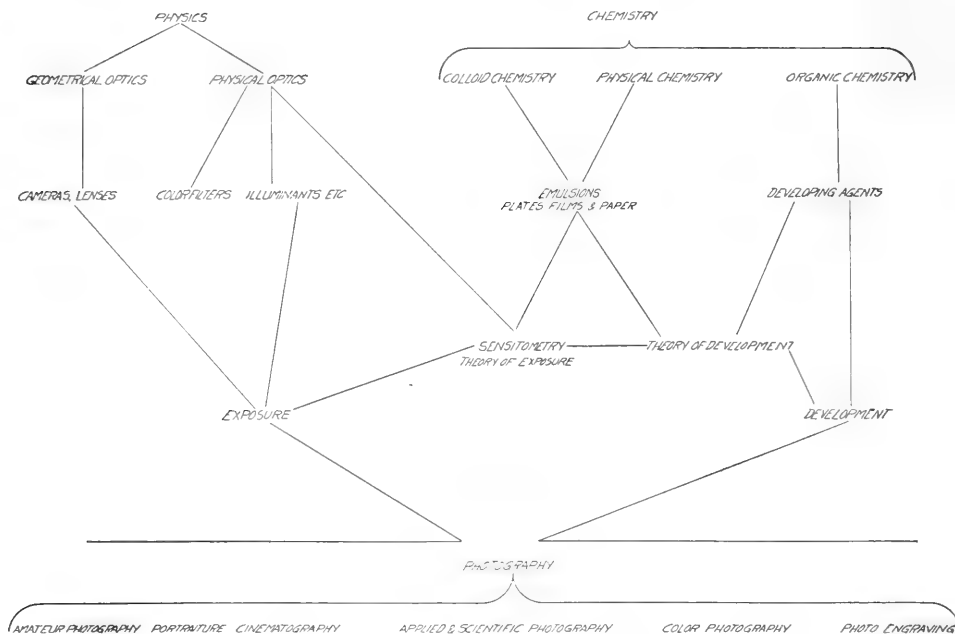


FIG. 1.

years by the research done by the photographic manufacturing firms, and it was in order to produce a considerable increase in the amount of this specialized photographic research work that the Eastman Kodak Company established its research laboratory.

The work of the laboratory deals, of course, not only with the theory of photography but with many points of practical importance both in the manufacture of photographic materials and apparatus and in their use, and the laboratory is divided into different sections corresponding to the general divisions of science, notably physics, chemistry and practical photography, the workers in these divisions collaborating in investigation of the problems with which the laboratory is concerned.

The branches of science which are of chief importance in photographic problems are those of optics in physics and of the colloid, physical and organic divisions of chemistry, and Fig. 1 represents an attempt to show the relations of these branches of science to photography.

Optics deals on its geometrical side with the materials used in photography—cameras, lenses, shutters, etc.—and on its physical side with such materials as color filters and illuminants, but especially with the study of the relation of the photographic image to the light by means of which it was produced—a study which is known by the name of sensitometry.

interlocked by their common members, who are dealing with a number of different lines of work.

The total work of the laboratory during the year may be represented by Fig. 3.

The departments of the laboratory are represented as circles on the outside of the chart, the main divisions in which problems group themselves being represented by the rectangles, subdivided in some instances, occupying the middle of the chart. Each of these rectangles corresponds to a morning conference; thus on Thursday mornings a conference is held on general photography, at which there are present members of the photographic department, the physics department, and the emulsion and coating or manufacturing departments. There is present at the conference, in fact, every scientific worker of the laboratory, whatever his rank, who is directly engaged on the subjects which are included under the head of general photography, and in some cases, or on special occasions, members of the staff of the company external to the laboratory are invited to these conferences, although it is not possible for many of them to be regularly present. All the main lines of investigation are laid down at these conferences and the progress from week to week carefully discussed. By the use of this system full cooperation and concentration of the different sections of the laboratory upon the problems to study which it has been founded is ensured.

Since the establishment of the laboratory, which was completed in 1913, a good deal of work has been finished and the foundations laid for much further research which can now be considered to be planned and arranged.

The work of the laboratory is published in the form of scientific papers, these being printed in the usual technical journals to which the special subject of the paper may be appropriate, and then at intervals, as sufficient papers accumulate, full abstracts of all the papers are collected and published in a volume under the title of "Abridged Scientific Publications." At the time of writing, October, 1917, about 65 papers have been completed.

The scientific work of the laboratory can be classified under the headings of the physics of photography, the chemistry of photography, the reproduction of tone values by photography, and work on special photographic processes, including those required for photography in natural colors. In addition to this a considerable amount of research has been done in pure chemistry and in the various branches of applied optics which are closely allied to photography.

THE PHYSICS OF PHOTOGRAPHY

Photographic sensitive surfaces do not consist of continuous coherent films of homogeneous material but have a definite granular structure, the sensitive material itself consisting of grains embedded in an insensitive matrix, so that in considering the properties of a sensitive photographic material we are considering really the properties of a collection of sensitive grains, which may differ considerably from each other in their individual properties. The properties of such a collection will be the statistical average of the individuals composing it and in order to understand the properties of a sensitive material we must therefore consider the properties of the individual grains and their relation to the aggregate material of which they are units.

The question at once arises: Do these grains consist of crystals of pure silver halide or of a gelatine silver complex? Microscopical study shows it to be probable that the grain is a pure silver halide crystal, for when these crystals are exposed to the action of water no swelling at all is observable even under the highest power of the microscope. The grains of silver bromide prove to be regular semi-transparent crystals belonging to the isometric system, occurring chiefly in triangular and hexagonal tablets and in needles of various thick-

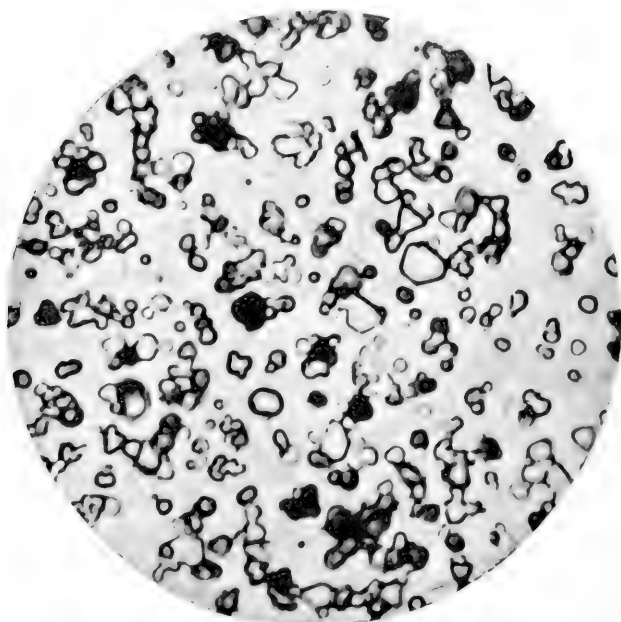


FIG. 4. PHOTOMICROGRAPH SHOWING SILVER BROMIDE CRYSTALS IN PHOTOGRAPHIC EMULSION.

nesses, these needles being formed in the same way as the tablets (see Fig. 4). As they occur in a gelatine emulsion, these grains are doubly refracting, though this would not have been expected from their crystalline form (see Fig. 5). Silver

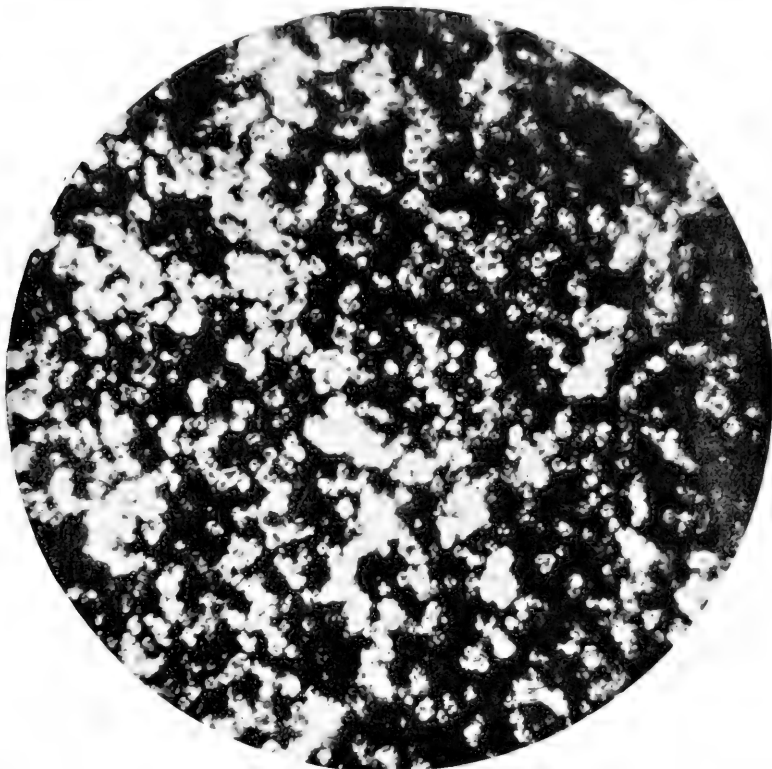


FIG. 5. PHOTOMICROGRAPH OF CRYSTALS OF SILVER BROMIDE BY POLARIZED LIGHT SHOWING DOUBLE REFRACTION

bromide can be crystallized out from its solution in ammonia to show all the forms in which it occurs in emulsions, and the physical chemistry of the preparation of these crystalline grains is under investigation in the laboratory at the present time.

When the silver halide grains are developed, the crystalline form is lost, the silver being deposited in a sponge-form in soot-like particles, the form of the deposit being generally considerably distorted from the original shape of the silver bromide crystal grain, though in some cases the original shape is fairly well reproduced in the deposit of metallic silver.

In viewing a negative by transmitted light we can not, of course, see these isolated grains with the naked eye but we see a conglomeration caused by the penetration of light through the interstices between the grains distributed throughout the

emulsion layer, and thus we obtain regular large patches or chains of grain, the pattern and regularity depending upon the particular type of emulsion used. This granularity, the formation of which can be studied by the examination of a vertical section through the film, is what is meant by the "graininess" of photographic negatives in general and is the grain met with in enlarging, in projection, and in portraiture.

The granular structure of a photographic emulsion involves a limit to the resolving power of the emulsion; that is, it requires a certain finite distance between two points of light falling upon the film in order that they may record themselves as separate deposits of silver grains. The study of the resolving power of a photographic emulsion can be accomplished by the examination of the spread of the edge of an image. Suppose, for instance, that we lay upon a photographic film a knife edge and then illuminate this knife edge vertically from above; some of the light passing the knife edge will be scattered into the shadow by reflection from the grains of silver bromide and will produce developable grains within the shadow so that upon development we shall obtain a distinct extension of the image beyond the edge into the shadow. If we determine the relation between the number of grains rendered developable and the distance from the edge, we shall have a relation which will depend upon the scattering of the light by the silver bromide grains and upon the absorption of that light by the grains. These two factors we might term the "turbidity" and "opacity" of the emulsion.

An emulsion having high turbidity and low opacity will have a very low resolving power. On the other hand, even if the emulsion has high turbidity, if its opacity is also high, the resolving power may be good. A typical example of this is the wet collodion plate, in which the turbidity is considerable but the opacity of the silver iodide for blue-violet light is so great that the resolving power is high. In the grainless Lippmann emulsion the resolving power is high if the emulsion is very clear, because the turbidity is very small, but the opacity is also small so that the slightest increase in turbidity may make the resolving power very low.

A convenient way of measuring resolving power is to photograph a converging grating, observing the point in the photograph at which resolution first occurs, from which a numerical measurement of the resolving power can be obtained.

The importance of photographic resolving power in relation to many branches of scientific work and especially spectro-

scopy and astronomy is obvious, and much work is being done in the laboratory upon these applications.

Of course, the fundamental problem in the physics of photography is the effect of the light on the film itself; that is to say, the change which occurs in a grain of silver bromide when it is exposed to light that makes it developable. It is extremely difficult to attack this directly, and the only possibility of evidence which we have been able to get is a statistical calculation by Dr. Nutting as to the amount of light which will produce a developable grain of silver bromide. Consider the exposure to light which is sufficient after full development to produce a deposit of unit density, that is, one which will transmit one tenth of the incident light.

A deposit which has this density contains 10 milligrams of metallic silver per square decimeter, or one tenth milligram per square centimeter, which represents roughly 10^{19} molecules of silver, or 10^7 grains 3μ in diameter. Now, the energy of the amount of violet light required to give an exposure necessary to make an emulsion film developable to this density is of the order of 10^{-7} ergs per square centimeter. Therefore, each grain (which contains on the average 10^{12} molecules) receives 10^{-14} ergs to make it developable. We know that in order to detach one electron from a molecule, 5×10^{-12} ergs are required in a gas; but this is a maximum amount and it is possible that in the exposure of a photographic plate 10^{-14} ergs are sufficient to detach one electron. Clearly, then, the energy incident on a grain during exposure may be sufficient to affect only one molecule in that grain, and the latent image may be composed of grains in each of which, on the average, only one molecule has lost an electron by the action of light.

THE CHEMISTRY OF PHOTOGRAPHY

While the grain structure of the emulsion and its reaction to light must be considered a branch of physics, the development of the emulsion is certainly closely related to physical chemistry. One of the most interesting pieces of work in the laboratory has been the study of the photographic developers in relation to their behavior in the development of the latent image, and the relation of the constitution of the many compounds possible to their properties is being attacked in the laboratory by the collaboration of the department of organic chemistry, which prepares the compounds in question, and of a special laboratory which deals with the physical chemistry of developers. In this laboratory the developers are examined

both by their action upon the photographic emulsion and also by the recognized methods of physical chemistry. The most fundamental property of a developing agent is its reduction potential, and this should apparently be measurable electrically by comparing the electromotive force produced on a platinized cathode immersed in the developing agent with the potential of an electrode charged with gaseous hydrogen.

The rate of development is dependent on two factors: first, on the rate of the chemical reaction itself; that is, on the solution of silver bromide, its conversion into metallic silver, and the precipitation of the metallic silver in a solid form; and, secondly, on the rate of diffusion of the developer to the silver bromide grain and of the products of development away from the grain. The second of these factors has by far the greater influence in settling the rate of development, though the time of first appearance of the image appears to be dependent chiefly upon the rate at which the developer attacks the silver bromide grain. It is in the rate of attack on the silver bromide grain that the reduction potential plays so great a part, but this rate of attack under ordinary conditions is limited by the rate of solution of the silver bromide, and a developer does not attack the silver bromide grain proportionally faster by reason of an increased reduction potential.

The reduction potential of a developer, in fact, may be compared to the horse power of an automobile, which for other reasons than the power of its engine is limited in speed. If we have two automobiles and they are confined to a maximum speed of twenty miles an hour, then on flat roads the one with the more powerful engine may be no faster than the weaker, but in a high wind or on a more hilly road the more powerful engine will allow the automobile to keep its speed, while with a weaker engine the speed would fall off; we can, indeed, measure the horse power of an automobile by the maximum grade which it can climb at a uniform speed. In development the analogy to the hill is the addition of bromide to the developer, since the addition of bromide, by the lowering of the solubility of the silver bromide, greatly delays the chemical reaction in development, and the higher the reduction potential of a developer, the more bromide is required to produce a given lowering of the density, so that we can measure the reduction potential by the amount of bromide required to produce a given effect. If we measure the common developers in this way, we shall find that glycin has the lowest reduction potential, then hydrochinon, then pyro and paraminophenol, and finally elon and diamidophenol have the highest.

THE REPRODUCTION OF TONE VALUES

The aim of photography is to reproduce in the print the scale of light intensities which occurs in the original subject, and the study of the way in which a scale of brightnesses is reproduced in the photographic process from the original subject through the negative to the print is necessarily the main study of a photographic research laboratory.

There are four separate sections involved in this investigation: first, the study of the range of brightnesses occurring in natural objects such as one is required to photograph; second, the study of the way in which the photographic emulsion translates a scale of light intensities into deposits of metallic silver in the negative; third, the study of the properties of photographic printing papers and the relation of the reflecting power of the deposits obtained in them to the scale of light intensities to which they were exposed; and, fourth, the study of the accuracy with which the tone values of the original are rendered through the negative on to the printing paper.

Until recently the scale of rendering of the negative material itself was all that had been fully investigated. This was done by Hurter and Driffeld in their famous photo-chemical investigation published in 1890, in which they measured the relation between the exposure of the sensitive material to light and the optical density produced. This density they defined as being the logarithm of the reciprocal of the transparency, and

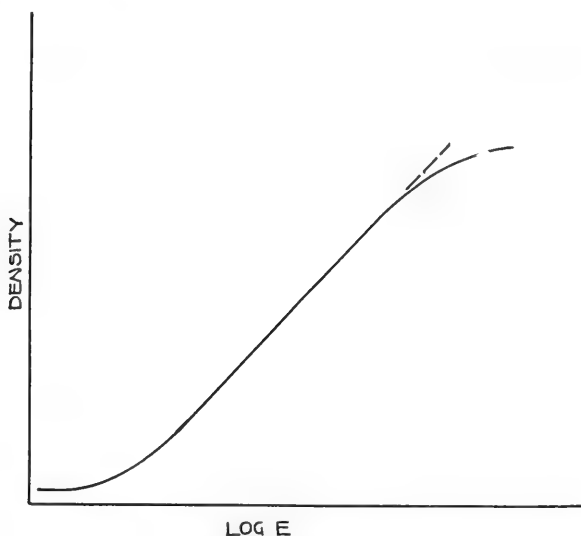


FIG. 6. CHARACTERISTIC CURVE OF PHOTOGRAPHIC PLATE SHOWING DENSITY EXPOSURE RELATIONS.

they found that it was proportional to the mass of silver per unit area. In their curves they plotted the density against the logarithm of the exposure, thus obtaining a curve which for the greater portion of its length is a straight line, though at the beginning and the end it departs from the straight line law (Fig. 6). It is only where the curve is a straight line that correct translation of the light intensities of the original into the density of the negative occurs. The study of these relations is what is known as "sensitometry" and forms a large part of photographic investigation in itself.

Much work has been done in the laboratory on the effect of development on the rendering of tone values in the negative and especially of development in those solutions which produce a somewhat colored image. If a negative be developed with pyrogallic acid the image produced is of a yellowish color, and it has a very different contrast when printed on the usual violet-sensitive photographic materials to that which is obtained when it is measured optically by means of the eye. The study of the relation of the photographic to the visual density of such images has in itself involved a very considerable amount of investigation.

In order to render possible the study of the reproduction occurring in photography an investigation of the sensitometry of papers was necessary.

In the first place, an instrument was designed by means of which the light reflected from small areas of the exposed print could be measured. Papers were then exposed for known periods of time, developed, the reflecting power of the developed image measured and curves plotted of the logarithm of the reciprocal of the reflecting power against the logarithm of the exposure. Several constants were found to express the behavior of photographic papers; thus, any paper had a maximum density, that is a minimum reflecting power representing the deepest black which could be obtained upon it. It showed also a typical scale or total range of exposures through which any difference could be obtained with an alteration of exposure. Again, the straight line portion of the curve showed a definite steepness or "gamma," as we call it, and finally the length of the straight line portion is of great importance, since it is only throughout this straight line portion that exact reproduction can be obtained (Fig. 7).

As a result of the work which has been done we are now able to give a complete solution for the translation of the scale of tone values of an original subject through the negative on to

the printing paper, showing how far the light reflected from the deposits in the print will correspond to the brightness existing in the original subject, and finding the effect of alterations in either the negative-making material or in the printing medium on the accuracy of the reproduction, as well as the effect of differences of development and exposure. A series of papers dealing with the whole subject of tone reproduction is in preparation at the present time.

Other branches of sensitometry are under investigation in the laboratory: thus, we have made a very careful study of the effect upon the sensitiveness of the photographic material of the variation of the wave length of the light to which it is ex-

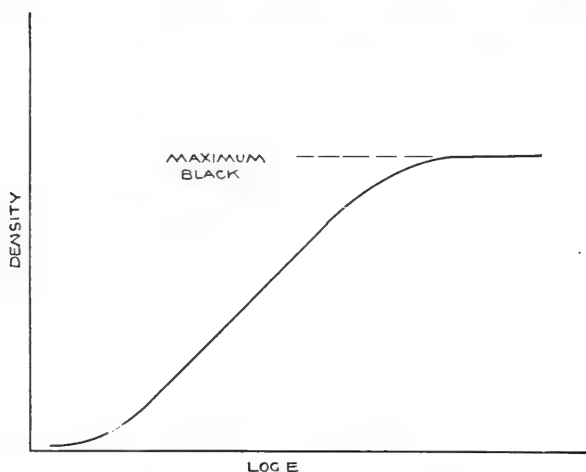


FIG. 7. CHARACTERISTIC CURVE OF PHOTOGRAPHIC PAPER SHOWING DENSITY-EXPOSURE RELATIONS.

posed, and for this purpose have constructed a special wavelength sensitometer with which a number of different materials have been investigated throughout their entire range of sensitiveness.

The study of the sensitiveness of photographic materials towards the X-rays is of considerable importance and for this purpose we have built special sensitometers for radiographic work. In the older types of sensitometers the exposure was graduated by means of a rotating disk from which sectors of varying angle were cut out, but it is known that the intermittent exposures given by such an arrangement do not integrate correctly, the density produced by a number of small exposures being less than that produced by the corresponding exposures impressed continuously. In X-ray work, moreover, there is a danger of stroboscopic effects produced by the rotating sector

getting in phase with the X-ray generator, which delivers a pulsating current, and there has therefore been designed in the laboratory a new type of non-intermittent sensitometer in which the exposures are given automatically and continuously, and this has proved very useful for many kinds of work and especially for radiographic sensitometry.

PRACTICAL PHOTOGRAPHY

Naturally, a great portion of the work of the laboratory is concerned with photographic processes and work on all kinds of photographic processes is continually in progress. It is difficult to summarize this work in any brief form, but the work which is being done on color photography is perhaps especially worthy of note.

There are two main divisions of the practical processes of color photography: the processes which are known as "additive," in which the colors are produced by the superposition upon a projection screen or in the eye of beams of the primary colors, and the "subtractive" processes in which negatives taken through the primary filters are printed in colors complementary to those filters and these prints are then superposed.

Most of the work of the laboratory has dealt with the subtractive processes, though a good deal of research work has been done upon the filters required for the additive processes and upon such subjects as the color of mixtures of two nearly complementary colors, work which is of considerable interest in connection with the two color additive processes.

In work on the subtractive process of color photography some interesting results have been achieved in the photomicrography of stained sections, a two-color process having been developed which gives very good results for this purpose. The two-color subtractive process of color photography has also been applied to motion picture work, the pictures being made by using film coated on both sides with a sensitive emulsion, so that negatives taken through the red and green filters can be impressed in register on opposite sides of this double-coated film and then the double images after development can be transformed into dye images complementary in color to the filters through which the negatives were taken. In this way each picture on the film consists of two pictures of complementary colors which give the effect of a two-color subtractive picture. This process, of course, has the great advantage that film so made is suitable for projection in any ordinary motion-picture machine.

APPLIED OPTICS

Owing to the great importance of applied optics in all photographic work the physics department of the laboratory has done a good deal of research in relation to this subject.

One branch of applied optics which has not previously received the attention which it seems to deserve is the study of the sensitiveness of the eye to light, and since the sensitometry of the eye is comparable in many respects to that of photographic materials a special series of investigations have been made on this subject in the laboratory as a result of which we have obtained new data with regard to the change of sensitiveness of the eye with different levels of brightness and to the rate of adaptation of the eye when the illumination is changed. A very recent piece of work deals with the change in size of the pupil with the brightness.

In pure applied optics a number of studies have dealt with the reflection and transmission of light by diffusing media and with photometry and brightness measurements, the laboratory being especially well equipped to study absorption photometry both with and without a consideration of color. The study of color in all its branches has occupied a large part of the activities of the physics department. Thus, measurements have been made on the sensibility of the eye to color and to change of hue, and a number of investigations have been made on the use of the monochromatic colorimeter in the quantitative expression of color.

Light filters are of great importance in photography, and the manufacture of light filters for all purposes was commenced with the establishment of the laboratory and has been continued as one of the manufacturing activities of the laboratory since. Over one hundred differently colored light filters are made, including filters applicable to all branches of scientific work. Special filters are made for microscopy, spectroscopy, photometry, etc. The measurement on the spectro-photometer of the absorption curves, both of these filters, and of the organic dyestuffs from which they are prepared, has been a subject of a considerable amount of study, and many interesting results have been obtained both in the visible spectrum and in the ultra-violet.

The work done in the laboratory up to the present time is really, of course, initial work, since the laboratory has only been in active operation for four years, but it is possible already to see the tendency of the work of the laboratory to converge more and more closely upon the purely photographic problems

which present an ample field for the entire energy of the laboratory and it is probable that the output of work on photographic questions will steadily increase as more experience is accumulated in the handling of the problems involved.

In addition to the scientific work of the laboratory on the theory of photography, which is referred to in this paper, a great number of industrial questions and works' problems are, of course, referred to the research laboratory, and it has been found that an organization arranged for the study of the fundamental problems of the theory of photography is well suited to taking care of these works problems and practical questions as they arise, each problem being assigned to the specialist who appears best fitted to deal with it, and it is understood by all the men in the laboratory that a certain part of their time will necessarily be devoted to the study of problems originating in the commercial and manufacturing departments of the company.

THE WORK OF THE NORTH DAKOTA
BIOLOGICAL STATION AT DEVIL'S LAKE

By Professor R. T. YOUNG

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DEVIL'S Lake, the euphonious substitution for the Indian Minnewaukon, or Spirit Water, is the name of one of the countless glacial lakes of northern North America. It is located in latitude 48, longitude 99, in North Dakota, at an altitude of 1,424 ft., in the upland prairie, which rises gradually from the Red River Valley to the high tableland, which sweeps westward through Montana to the Rocky Mountains.

It was formed by a morainic dam built by the ice across an old river valley, and originally drained southward through Stump Lake into the Sheyenne River (Fig. 1). At one time during the retreat of the continental ice sheet the glacial lake

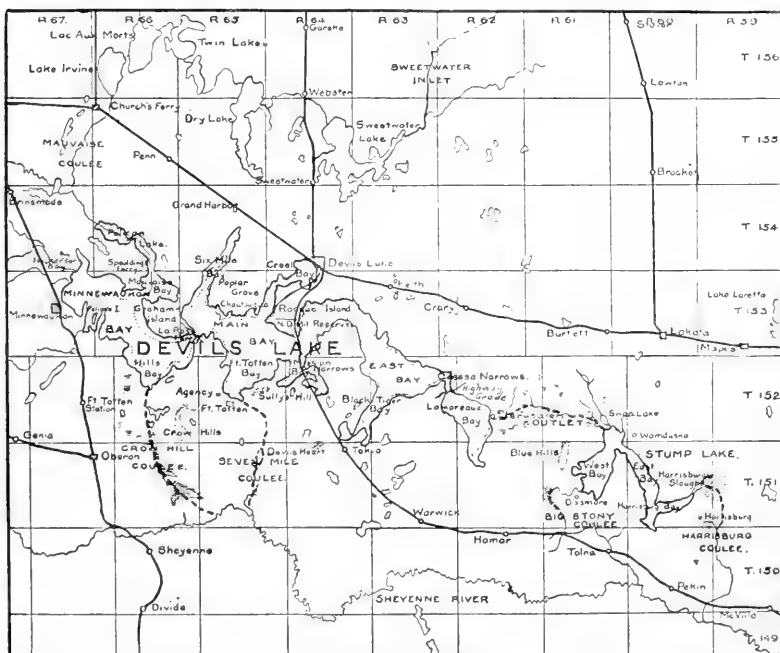


FIG. 1. MAP OF THE DEVIL'S-STUMP LAKE COMPLEX, showing the former connection of Devil's Lake with the Sheyenne River, via the Jerusalem outlet, Stump Lake and the Harrisburg Coulee. The full shore line is from the U. S. G. S. map of 1883. The dotted line shows the present shore line approximately. (From Simpson in N. D. G. S. Report for 1909-10.)

Souris, occupying a part of northern North Dakota and southern Manitoba west of the glacial lake Agassiz, found an outlet via the Mauvaise Coulée and the Devil's-Stump Lake basin into the Sheyenne River. With the disappearance of this lake the drainage area was restricted to about 3,500 square miles between Devil's Lake and the Turtle Mountains, a group of low morainic hills on the Canadian boundary.

With the retreat of the ice and consequent diminution of moisture, the evaporation of Devil's Lake came in time to exceed its supply, the connection with Stump Lake and the Sheyenne River was lost and its subsequent history has been in general one of gradual recession. Between 1885 and 1890, the connection with the Mauvaise Coulée was lost except during spring freshets, but the very heavy snowfall of 1916 has restored this.¹

There is considerable reason to believe that the recession of the lake has not been constant, but that at least one period has intervened when it was much lower than at present, if not entirely absent. The evidence for this is the existence of an old forest in Stump Lake, from which the lake derives its name (Figs. 2 and 3); the presence of a submerged terrace (indicative of a former shore line) in Devil's Lake, similar to those



FIG. 2. STUMP LAKE, showing remains of submerged forest, from which the lake derives its name. (Simpson, photo.)

¹ This coulée is again dry—1917.



FIG. 3. ONE OF THE STUMPS OF THE SUBMERGED FOREST IN STUMP LAKE.
(Simpson, photo.)

about its shores; and the existence of rock piles in the lake which were probably formed by ice action during periods of lower level (Fig. 4). With continued recession of the lake, many small ponds have been separated from the main body, and this process is still continuing. Three highway embank-



FIG. 4. ROCK PILE IN DEVIL'S LAKE. These glacial boulders have been piled up through ice action, and are evidence of a former lake level as low or lower than the present. (Simpson, photo.)

ments have recently been built across the lake, which together with its recession have divided it into four main parts. Taken as a whole the form of the lake is very irregular, several long arms extending out approximately at right angles to the central part.

The United States Geological Survey in 1883 estimated the area at 125 square miles, but its present area probably does not exceed 60 square miles. Its former maximum depth of 56 feet has now been reduced to 18 feet.

The recession of the lake has left its evidence upon its former shores in the form of terraces indicating the old beach lines. Two of these are easily traceable, and many smaller and less distinct may be found (Figs. 5 and 6).

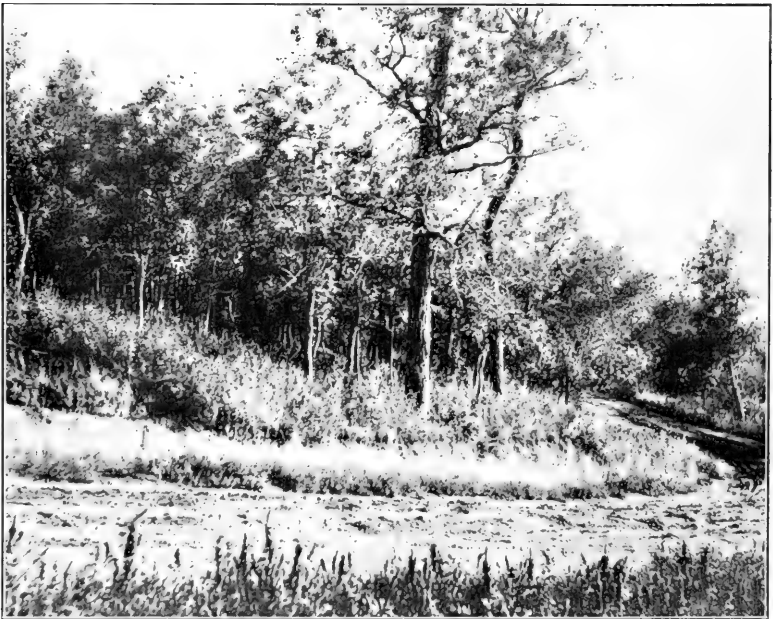


FIG. 5. THE "A" BEACH, THE HIGHEST LEVEL OF DEVIL'S LAKE. The highway is cut through the bank at the left. The water came to the foot of this bank. (From Simpson, N. D. G. S. Report for 1909-10.)

The climate of the region in which Devil's Lake lies is characteristic of inland plateaus. The precipitation averages 18 inches. The winters are long and cold, with a minimum temperature of -44° F.; the summers short, with generally cool nights and warm days, the thermometer occasionally reaching 100° F. in the shade. Many cool days occur in summer, however, frost in June and August, while unusual, being by no means unknown. Devil's Lake is ice-bound from the middle of

November to the middle of April, the ice commonly reaching a thickness of three feet. After breaking in the spring it is driven about the lake with great force by the high winds characteristic of the region, which occasionally reach a velocity of sixty miles an hour, and it is through this ice action in considerable measure that the rock "piles" are formed.



FIG. 6. THE SHORE OF DEVIL'S LAKE, showing recent beach lines (indicated by the zones of plant growth), and a sand spit formed by recession of the lake level. (Young, photo.)

As a result of the recession of the lake a great concentration in its salt content is occurring. The present amount of total solids is about 15,000 parts per million, consisting largely of the sulphates of sodium and magnesium, and sodium chloride. The specific gravity is 1.014 and the osmotic pressure 6.5 atmospheres.² These figures vary somewhat from time to time dependent on the lake level. In spite of its alkaline character the water is drunk to some extent by cattle. The chemical character of the various parts into which the lake is divided varies widely, dependent upon different factors, such as date of separation from the main body, character of shores with consequent amount of run off, and depth.

To the physiographer Devil's Lake is of great interest, showing as it does so clearly the evidence of its past history, with the same processes in action at present; but to the biologist it is of even greater interest by reason of the changes in its inhabitants, which are accompanying the changes in its physical and chemical condition.

Previous to 1883 the lake swarmed with pickerel, but shortly subsequent to that date and coincident with a rapid decrease in the lake level, they suddenly disappeared.

² These data refer to the main part of Devil's Lake.

In order to ascertain, if possible, the cause of their disappearance, to investigate the possibility of restocking the lake with fish and to study the many problems of scientific interest presented by it as well as by other waters in the state, the legislature of 1909 made an appropriation of \$5,000 for the construction of a building, beside \$3,000 annually for maintenance.

The building (Fig. 7) is a tasteful two-story structure, the lower story being constructed of boulders from the lake shore

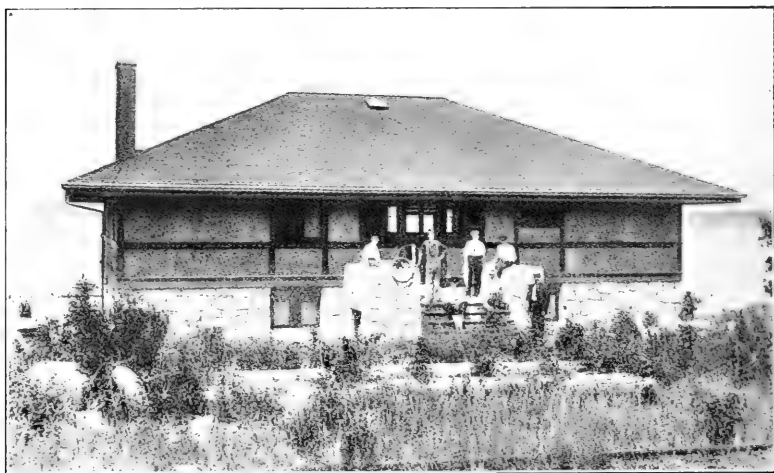


FIG. 7. NORTH DAKOTA BIOLOGICAL STATION AT DEVIL'S LAKE. (From Brannon, Report of the Biological Station for 1909-10.)

and the upper of frame covered with stucco. It contains a small hatchery equipped for handling several million eggs at one time, a small museum of local animals, a large assembly room, five rooms for private workers, beside a director's office, and a chemical laboratory.

The equipment, while simple, is adequate for the purposes for which it is designed.

The investigations of the station have covered three main lines—experiments in restocking the lake with fish, studies on the effects of environment and isolation on Crustacea and studies of the plankton and its environment.

For a number of years sporadic attempts at stocking the lake have been made by residents of the vicinity, and in 1907 the U. S. Bureau of Fisheries sent a field party to study the lake and report upon the feasibility of planting fish in it. They found that several species of fish could live in the lake for a number of weeks.³

³ See Pope, T. E. B., "Devil's Lake, North Dakota." Bur. of Fish, Doc. 634, 1907.

Since the establishment of the station experiments in restocking have been carried on by the former director, Dr. M. A. Brannon and by the writer.

These experiments have shown that when conditions are favorable—if the fish are in good condition on arrival and the water is cool (less than 65° F.), it is possible to introduce them directly into lake water with very little loss. On the contrary, when the fish suffer from high temperature or insufficient oxygen in transit, and reach the lake in poor condition better results are obtained by holding them for several days in concrete tanks, where they are gradually acclimatized to the lake water. This method also appears to be safer for the very young fish (six to eight weeks old), while older fish (one year or more) will bear direct transfer if conditions are favorable.

Beside the experiments with fingerlings and older fish, a large number of the pike perch and yellow perch have been hatched and transferred to the lake. While under observation in the hatchery jars or troughs, a large percentage of the eggs hatch nicely and the young fish are active and appear perfectly healthy. Owing to difficulties in keeping these very small fish in aquaria or cages it has not yet been possible to hold them for observation for any considerable time after hatching, but it is probable that some means may be devised for doing this in future. The experiments have been conducted mainly with yellow perch, both because of its ability to live in the lake and the available supply; but it has been found that other species (catfish, black bass, rainbow and steel head trout and pike perch) will under favorable conditions live in the lake.

These experiments are of great interest in their bearing on the ability of fish to withstand changes in the density of water.

The problem of the transfer of organisms between media of different densities opens up a wide field of investigation and has led to much experiment thus far and to many conflicting results. What are the factors involved in such transfer? Is it purely a question of osmotic pressure, or of chemical action between the body fluids and the surrounding media? What is the rôle of salts in the preservation of life? Do they act upon the organism independently of each other or is there a combined effect? Is it possible to accustom all organisms to changes in density of their surrounding media, or are some of them closely circumscribed in this respect, and what are the limits of such adaptability? If differences in this respect exist in different organisms, to what are they due? What is the relative effect of sudden and gradual changes in density? These are some of the many questions involved in this problem.

The experiments at Devil's Lake have shown clearly that many species of fish can withstand changes in density of about .011, that the ability of the fish to withstand such changes is largely dependent on the temperature and on the condition of the fish at the time, and that marked differences exist between individual fish in this respect.

The reasons for the disappearance of the pickerel can not be stated with certainty. Coincident with their disappearance a marked decrease in lake level took place. This cut off the coulée coming in from the lakes northward in which the pickerel bred. Previous to their disappearance they were taken from the lake in large numbers without restriction, and this fact coupled with the loss of their breeding grounds is sufficient in some measure to explain their disappearance. It does not, however, explain the suddenness of their disappearance, which, according to all reports, took place between 1885 and 1889. It is probable, therefore, that some epidemic was the third factor in their reduction. Regarding this it is of course impossible to obtain definite information now.

A second line of work conducted by the station is the study of the variation produced in organisms by changes in the physico-chemical character of their environment and by isolation, using for this purpose mainly the copepod *Diaptomus* (Fig. 8).

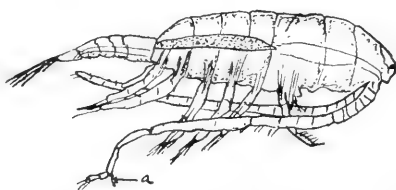


FIG. 8. *Diaptomus* (MALE) SHOWING PROCESS, *a*, OF THE RIGHT ANTENNA. The length of this process, together with that of the antenna and the body, shows marked differences in inhabitants of different ponds, as the result of differences in environment and of isolation. Magnified 50 diameters. (Moberg, del.)

A large number of these from ten of the separate parts of the lake collected in all seasons of the year have been carefully measured and compared. The following data have been chosen for such comparison: length of body, antennæ and process of right antenna in the male.

This study has shown clearly a distinct variation in all of these dimensions as the result of such changes in environment, the length of the process of the antenna of the male varying directly, while the length of the antenna varies inversely as the length of body.

These results are consistent with those of many other

workers respecting the influence of environment and isolation in modifying organisms. They open up a wide field of further observation and experiment, such as the transfer of organisms from one pond to another to determine whether the differences are constant or reversible; the gradual increase in density of the water to determine how soon such increase shows its effect, and whether it has any other effects in influencing the sex and number of offspring in successive generations, etc.; a comparison of the differences found between organisms in lakes far distant and those in the Devil's Lake complex; a study of the developing organisms in the various ponds to determine whether the larvæ show differences comparable with those of the adults; these are some of the many interesting and important problems waiting to be solved. Such questions, while seemingly of interest only to the specialist, are nevertheless of profound importance to all of us, for they seek to answer in some measure the ever-vexing question of "nature vs. nurture." If it is reasonable to believe that all protoplasm is fundamentally alike, however widely it may differ in its manifold forms and reactions, then the solution of this question of the relative part played by heredity and environment in the development of even so humble a creature as a little shrimp-like animal about one twentieth of an inch in length, should aid in answering the same question in human development. The fact that in the Devil's Lake complex we have in many cases an exact, and in all a fairly accurate record of the time that nature has been performing these isolation experiments for us, and that we have ready made, as it were, a large number of experimental ponds in which to conduct further experiments of our own, renders this region an unusually favorable one in which to study the problem.

The plankton, the minute free-swimming organisms, in the lake has been extensively studied in its relation to its environment. These studies comprise over 800 collections from all parts of the main body of the lake and several of the outlying ponds. These have been taken both by day and by night, at all times of year, including midwinter. The organisms contained in these collections are now being counted, after which a comprehensive report will be prepared. Coincident with many of these collections determinations of temperature, dissolved gases, etc., have been made. Studies of the plankton have brought out clearly the interesting fact that these minute organisms frequently occur in swarms, the causes of which are not at present clear. In two regions separated by only a few feet may

occur immense numbers, especially of the cladoceran *Moina*, while the intervening areas may be comparatively free from it. Differences as great as 400 per cent. may occur between two places seemingly alike in every respect. So far as can be determined, there is no difference either in chemistry, physics or food supply to determine these differences. Their explanation must therefore be sought in some as yet obscure biological factor.

Some preliminary studies have also been made of the Red and Missouri rivers and of other waters in North Dakota, but the main activities of the station have been confined to Devil's Lake and its adjacent waters.

The fauna and flora of the lake are interesting both in respect to what they do, and do not contain. The only vertebrate inhabitants are the stickleback, the leopard frog and the salamander *Amblystoma*. Among the invertebrates the crustaceans, insects and rotifers are each represented by several species. One of the latter *Brachionus*, named from its habitat *satanicus* by Mr. Rousselet of London, is new to science. A few extinct mollusks occur and at least one arachnid, but the coelenterates, sponges, polyzoans and annelids are apparently entirely absent, and thus far but one free-living flatworm has been found. Nematodes on the contrary are common, and include several species as yet only partially determined. The animal phylum most largely represented is the protozoa. These include chiefly ciliates and flagellates, many of which are as yet indeterminate and probably represent new species. The rhizopods are poorly represented, *Arcella vulgaris* being the only one which occurs at all commonly. This is the more remarkable in view of the fine layer of ooze covering the lake floor. The fact that this layer is occasionally lacking in free oxygen may explain their absence, but Juday's observations¹ on animals living in water lacking free oxygen, and the presence of several other protozoa in the ooze in Devil's Lake, render this explanation somewhat questionable. One of the commonest animals in the lake, the midge *Chironomus*, occurs as a larva exclusively in this ooze.

The ditch grass (*Ruppia*) grows abundantly in the shallower parts of the lake, forming a tangled mass, which in some places prevents navigation with power boats. There are many species of unicellular algæ; some of which, especially the blue-greens, are very abundant. It is difficult to assign to any one

¹ Juday, C., "Some Aquatic Animals that Live under Anærobic Conditions," *Trans. Wis. Acad. Sci.*, XVI., p. 11.

group of plants the most important part in the life of the lake, although the diatoms with some fifty species take first place in respect to variety and play a very important part as food for the animals.

The busiest part of the lake, biologically speaking, is the *Ruppia* zone which occurs in depths of from two to five feet. Here is the nesting place of the stickleback. Attached to the *Ruppia* are masses of the filamentous green alga *Cladophora*, while to this again are attached numerous sessile diatoms and protozoans. Many free-swimming protozoans, rotifers, nematodes and copepods also occur here; some by chance as they are driven hither and yon by the currents in the lake, others finding favorable shelter in the tangled mass of *Ruppia* and *Cladophora*, and seldom occurring elsewhere.

The rocky islands are the breeding homes of cormorants, ducks and terns, while many other species of water fowl breed abundantly in the marshes, which in some places occupy the old lake bottom. The cormorant colony on "Bird Island," as it is known, is one of the most interesting places about the lake



FIG. 9. BIRD ISLAND IN DEVIL'S LAKE, the home of the double-crested cormorant, whose nests may be seen among the rocks. (Young, photo.)

(Fig. 9). On the approach of the intruder the old birds, and such of the young as are able, scramble off into the water, while the birds which are too young to leave the nest voice their

protests in inarticulate squawking, at the same time disgorging masses of sticklebacks and young salamanders, which form their staple diet. The nests, rude piles of sticks, are crowded together among the rocks. After the breeding season gulls, ducks and terns gather in flocks about the lake, and together with migrant phalarope and sandpipers form a busy and restless population. Some of the flocks of ducks are so large that as they take wing they make a sound like rushing water.

On the southern shore is a long low ridge of morainic hills, the highest point of which is named "Sully's Hill" after General Sully, the old Indian fighter (Fig. 10). The major part of



FIG. 10. DEVIL'S LAKE, shore strewn with glacial boulders in fore-ground. Sully's Hill National Park site in back-ground. (Young, photo.)

this hill which is some three miles long has been set aside as a national park and fenced in for the retention of wild animals (elk, deer, bear, etc.) with which it is planned to stock it.

About two miles to the west of Sully's Hill is the old frontier Fort Totten, now used as an Indian school, while in wretched "shacks" scattered over the hills on the reservation still live some of the old warriors, who in days gone by hunted the buffalo and the white man over the vast plains of the Dakotas.

THE COMPLEXITY OF THE CHEMICAL
ELEMENTS, II

By Professor FREDERICK SODDY, M.A., F.R.S.

THE PERIODIC LAW AND RADIOACTIVE CHANGE

THE second line of advance interprets the periodic law. It began in 1911 with the observation that the product of an α -ray change always occupied a place in the periodic table two places removed from the parent in the direction of diminishing mass, and that in subsequent changes where α -rays are not expelled the product frequently reverts in chemical character to that of the parent, though its atomic weight is reduced 4 units by the loss of the α -particle, making the passage across the table curiously alternating. Thus the product of radium (Group II.) by an α -ray change is the emanation in the zero group, of ionium (Group IV.), radium, and so on, while, in the thorium series, thorium (Group IV.) produces by an α -ray change mesothorium-I (Group II.), which, in subsequent changes in which no α -rays are expelled, yields radio-thorium, back in Group IV. again.¹ Nothing at that time could be said about β -ray changes. The products were for the most part very short-lived and imperfectly characterized chemically, and several lacunæ still existed in the series masking the simplicity of the process. But early in 1913 the whole scheme became clear, and was pointed out first by A. S. Russell, in a slightly imperfect form, independently by K. Fajans from electro-chemical evidence, and by myself, in full knowledge of Fleck's results, still for the most part unpublished, all within the same month of February. It was found that, making the assumption that uranium-X was in reality two successive products giving β -rays, a prediction Fajans and Göhring proved to be correct within a month, and a slight alteration in the order at the beginning of the uranium series, every α -ray change produced a shift of place as described, and every β -ray change a shift of one place in the opposite direction. Further and most significantly, when the successive members of the three disintegration series were put in the places in the table dictated by these two rules, it was found

¹ "Chemistry of the Radio-Elements," p. 29, first edition, 1911.

that all the elements occupying the same place were those which had been found to be non-separable by chemical processes from one another, and from the element already occupying that place, if it was occupied, before the discovery of radioactivity. For this reason the term "isotope" was coined to express an element chemically non-separable from the other, the term signifying "the same place."

So arranged, the three series extended from uranium to thallium, and the ultimate product of each series occupied the place occupied by the element lead. The ultimate products of thorium should, because six α -particles are expelled in the process, have an atomic weight 24 units less than the parent, or about 208. The main ultimate product of uranium, since eight α -particles are expelled in this case, should have the atomic weight 206. The atomic weight of ordinary lead is 207.2, which made it appear very likely that ordinary lead was a mixture of the two isotopes, derived from uranium and thorium. The prediction followed that lead, separated from a thorium mineral, should have an atomic weight about a unit higher, and that separated from uranium minerals about a unit lower, than the atomic weight of common lead, and in each case this has now been satisfactorily established.

THE ATOMIC WEIGHT OF LEAD FROM RADIOACTIVE MINERALS

It should be said that Boltwood and also Holmes had, from geological evidence, both decided definitely against it being possible that lead was a product of thorium, because thorium minerals contain too little lead, in proportion to the thorium, to accord with their geological ages. Whereas, the conclusion that lead was the ultimate product of the uranium series had been thoroughly established by geological evidence, and has been the means, in the hands of skilful investigators, of ascertaining geological ages with a degree of precision not hitherto possible. Fortunately I was not deterred by the *non possumus*, for it looks as if everybody was right! An explanation of this paradox will later be attempted. In point of fact, there are exceedingly few thorium minerals that do not contain uranium, and since the rate of change of uranium is about 2.6 times that of thorium, one part of uranium is equal as a lead-producer to 2.6 parts of thorium. Thus Ceylon thorianite, one of the richest of thorium minerals, containing 60 to 70 per cent. of ThO_2 , may contain 10 to 20 and even 30 per cent. of U_3O_8 , and the lead from it may be expected to consist of very similar quan-

tities of the two isotopes, to be in fact very similar to ordinary lead. I know of only one mineral which is suitable for this test. It was discovered at the same time as thorianite, and from the same locality—Ceylon thorite, a hydrated silicate containing some 57 per cent. of thorium and 1 per cent. of uranium only. In the original analysis no lead was recorded, but I found it contained 0.4 per cent., which, if it were derived from uranium only, would indicate a very hoary ancestry, comparable, indeed, with the period of average life of uranium itself. On the other hand, if (1) all the lead is of radioactive origin, (2) is stable, and (3) is derived from both constituents, as the generalization being discussed indicated, this 0.4 per cent. of lead should consist 95.5 per cent. of the thorium isotope and 4.5 per cent. of the uranium isotope. Thorite thus offered an extremely favorable case for examination.

In preliminary experiments in conjunction with H. Hyman, in which only a gram or less of the lead was available, the atomic weight was found relatively to ordinary lead to be perceptibly higher, and the difference, rather less than one half per cent., was of the expected order.

I was so fortunate as to secure a lot of 30 kilos of this unique mineral, which was first carefully sorted, piece by piece, from admixed thorianite and doubtful specimens. From the 20 kilos. of first grade thorite, the lead was separated, purified, reduced to metal, and cast *in vacuo* into a cylinder, and its density determined together with that of a cylinder of common lead similarly purified and prepared. Sir Ernest Rutherford's theory of atomic structure, to be dealt with in the latter part of this discourse, and the whole of our knowledge as to what isotopes were, made it appear probable that their atomic volumes, like their chemical character and spectra, should be identical, and therefore that their density should be proportional to their atomic weight. The thorite lead proved to be 0.26 per cent. denser than the common lead. Taking the figure 207.2 for the atomic weight of common lead, the calculated atomic weight of the specimen should be 207.74.

The two specimens of lead were fractionally distilled *in vacuo*, and a comparison of the atomic weights of the two middle fractions made by a development of one of Stas's methods. The lead was converted into nitrate in a quartz vessel, and then into chloride by a current of hydrogen chloride, in which it was heated at gradually increasing temperature to constant weight. Only single determinations have been done, and they gave the values 207.20 for ordinary lead, and 207.694

for the thorite lead, figures that are in the ratio of 100 to 100.24. This therefore favored the conclusion that the atomic volume of isotopes is constant.

At the request of Mr. Lawson, interned in Austria, and continuing his researches at the Radium Institut under Professor Stefan Meyer, the first fraction of the distilled thorite lead was sent him, so that the work could be checked. He reports that Professor Hönigschmid has carried through an atomic weight determination by the silver method, obtaining the value 207.77 ± 0.014 , as the mean of eight determinations. Hence, the conclusion that the atomic weight of lead derived from thorite is higher than that of common lead has been put beyond reasonable doubt.

Practically simultaneously with the first announcement of these results for thorium lead, a series of investigations were published on the atomic weight of lead from uranium minerals, by T. W. Richards and collaborators at Harvard, Maurice Curie in Paris, and Hönigschmid and collaborators in Vienna, which show that the atomic weight is lower than that of ordinary lead. The lowest result hitherto obtained is 206.046, by Hönigschmid and Mlle. Horovitz for the lead from the very pure crystallized pitchblende from Morogoro (German East Africa), whilst Richards and Wadsworth obtained 206.085 for a carefully selected specimen of Norwegian clevite. Numerous other results have been obtained, as, for example, 206.405 for lead from Joachimsthal pitchblende, 206.82 for lead from Ceylon thorianite, 207.08 for lead from monazite, the two latter being mixed uranium and thorium minerals. But the essential proportion between the two elements has not, unfortunately, been determined. Richards and Wadsworth have also examined the density of their uranium lead. In every case they have been able to confirm the conclusion that the atomic volume of isotopes is constant, the uranium lead being as much lighter as its atomic weight is smaller than common lead. Many careful investigations of the spectra of these varieties of lead show that the spectrum is absolutely the same so far as can be seen.

THORIUM AND IONIUM

A second quite independent case of a difference in atomic weight between isotopes has been established. It concerns the isotopes thorium and ionium, and it is connected in an important way with the researches which, on two previous occasions, I have given an account of here, the researches on the

growth of radium from uranium, which have been in progress now for fourteen years. It is the intervention of ionium and its very long period of life which has made the experimental proof of the production of radium from uranium such a long piece of work. Previously only negative results were available. One could only say, from the smallness of the expected growth of radium, that the period of average life of ionium must be at least 100,000 years, forty times longer than that of radium, and, therefore, that there must be at least forty times as much ionium by weight as radium in uranium minerals, or at least 13.6 grams per 1,000 kilos of uranium. Since then further measurements, carried out by Miss Hitchens last year, have shown definitely for the first time a clear growth of radium from uranium in the largest preparation, containing 3 kilos of uranium, and this growth, as theory requires, is proceeding according to the square of the time. In three years it amounted to 2×10^{-11} grams of radium, and in six years to just four times this quantity. From this result it was concluded that the previous estimate of 100,000 years for the period of ionium, though still of the nature of a minimum rather than a maximum, was very near to the actual period.

Joachimsthal pitchblende, the Austrian source of radium, contains only an infinitesimal proportion of thorium. An ionium preparation separated, by Auer von Welsbach, from 30 tons of this mineral, since no thorium was added during the process, was an extremely concentrated ionium preparation. The atomic weight of ionium—calculated by adding to the atomic weight of its product, radium, four for the α -particle expelled in the change—is 230, whereas that of thorium, its isotope, is slightly above 232. The question was whether the ionium-thorium preparation would contain enough ionium to show the difference. Hönigschmid and Mlle. Horovitz have made a special examination of the point, first redetermining as accurately as possible the atomic weight of thorium and then that of the thorium-ionium preparation from pitchblende. They found 232.12 for the atomic weight of thorium, and by the same method 231.51 for that of the ionium-thorium. A very careful and complete examination of the spectra of the two materials showed for both absolutely the same spectrum and a complete absence of impurities.

If the atomic weight of ionium is 230, the ionium-thorium preparation must, from its atomic weight, contain 30 per cent. of ionium and 70 per cent. of thorium by weight. Professor Meyer has made a comparison of the number of α -particles

given per second by this preparation with that given by pure radium, and found it to be in the ratio of 1 to 200. If 30 per cent. is ionium, the activity of pure ionium would be one sixtieth of that of pure radium, its period some sixty times greater, or 150,000 years. This confirms in a very satisfactory manner our direct estimate of 100,000 years as a minimum, and incidentally raises rather an interesting question.

My direct estimate involves directly the period of uranium itself, and if the value accepted for this is too high, that for the ionium will be correspondingly too low. Now, last week, Professor Joly was bringing before you, I believe, some of his exceedingly interesting work on pleochroic halos, from which he has grounds for the conclusion that the accepted period of uranium may be too long. But since I obtained, for the period of ionium, a minimum value two thirds of that estimated by Meyer from the atomic weight, it is difficult to believe that the accepted period of uranium can have been overestimated by more than 50 per cent. of the real period. The matter could be pushed to a further conclusion if it were found possible to estimate the percentage of thorium in the thorium-ionium preparation, a piece of work that ought not to be beyond the resources of radio-chemical analysis. This would then constitute a check on the period of uranium as well as on that of ionium. Such a direct check would be of considerable importance in the determination of geological ages.

The period of ionium enables us to calculate the ratio, between the weights of ionium and uranium in pitchblende, as 17.4 to 10³, and the doctrine of the non-separability of isotopes leads directly to the ratio, between the thorium and uranium in the mineral, as 41.7 to 10³. This quantity of thorium is, unfortunately, too small for direct estimation. Otherwise it would be possible to devise a very strict test of the degree of non-separability. As it is, the work is sufficiently convincing. Thirty tons of a mineral containing a majority of the known elements in detectable amount, in the hands of one whose researches in the most difficult field of chemical separation are world-renowned, yield a preparation of the order of one millionth of the weight of the mineral, which can not be distinguished from pure thorium in its chemical character. Any one could tell in the dark that it was not pure thorium, for its α -activity is 30,000 times greater than that of thorium. This is then submitted to that particular series of purifications designed to give the purest possible thorium for an atomic weight determination, and it emerges without any separation of the

ionium, but with a spectrum identical with that of a control specimen of thorium similarly purified. The complete absence of impurities in the spectrum shows that the chemical work has been very effectively done, and the atomic weight shows that it must contain 30 per cent. by weight of the isotope ionium, a result which agrees with its α -activity and the now known period of the latter.

DETERMINATION OF ATOMIC WEIGHTS

The results enumerated thus prove that the atomic weight can no longer be regarded as a natural constant, or the chemically pure element as a homogeneous type of matter. The latter may be, and doubtless often is, a mixture of isotopes varying in atomic weight over a small number of units, and the former then has no exact physical significance, being a mean value in which the proportions of the mixture as well as the separate atomic weights are both unknown. New ideals emerge and old ones are resuscitated by this development. There may be, after all, a very simple numerical relation between the true atomic weights. The view that seems most probably true at present is that while hydrogen and helium may be the ultimate constituents of matter in the Proutian sense, and the atomic weights therefore approximate multiples of that of hydrogen, small deviations, such as exist between the atomic weights of these two constituent elements themselves, may be due to the manner in which the atom is constituted, in accordance with the principle of mutual electro-magnetic mass, developed by Silberstein and others. The electro-magnetic mass of two charges in juxtaposition would not be the exact sum of the masses when the charges are separated. The atomic weight of hydrogen is 1.0078 in terms of that of helium as 3.99, and that the latter is not exactly four times the former may be the expression of this effect. Harkins and Wilson have recently gone into the question with some thoroughness, and the conclusion of most interest in the present connection, which appears to emerge, is in favor of regarding most of the effect to occur in the formation of helium from hydrogen, and very little in subsequent aggregations of the helium. In the region of the radioelements, where we have abundant examples of the expulsion of helium atoms as α -particles, it seems as if we could almost safely neglect this effect altogether. Thus radium has the atomic weight almost exactly 226, and the ultimate product almost exactly 206, showing that in 5 α - and 4 β -ray changes the

mean effect is nil, and the atomic weights are moreover integers in terms of oxygen as 16, or helium 4. It is true that the atomic weights of both thorium and uranium are between 0.1 and 0.2 greater than exact integers, but it is difficult to be sure that this difference is real.

When, among the light elements, we come across a clear case of large departure from the integral value, such as magnesium 24.32 and chlorine 35.46, we may reasonably suspect the elements to be a mixture of isotopes. If this is true for chlorine, it suggests a most undesirable feature in the modern practice of determining atomic weights. More and more the one method has come to be relied upon: the preparation of the chloride of the element and the comparison of its weight with that of the silver necessary to combine with the chlorine, and with the weight of the silver chloride formed.

Almost the only practical method, and that a very laborious and imperfect one, which may be expected to resolve a mixture of isotopes, is by long-continued fractional gaseous diffusion, which is likely to be the more effective the lower the atomic weight. Assume, for example, chlorine were a mixture of isotopes of separate atomic weights 34 and 36, or 35 and 36. The 34 isotope would diffuse some 3 per cent. faster than the 36, and the 35 some 1.5 per cent. faster.

The determination of the atomic weight of chlorine in terms of that of silver has reached now such a pitch of refinement that it should be able to detect a difference in the end fractions of the atomic weight of chlorine, if chlorine or hydrogen chloride were systematically subjected to diffusion. It is extremely desirable that such a test of the homogeneity of this gas should be made in this way.

Clearly a change must come in this class of work. It is not of much use starting with stuff out of a bottle labeled "purissimum" or "garantirt," and in determining to the highest possible degree of accuracy the atomic weight of an element of unknown origin. The great pioneers in the subject, like Berzelius, were masters of the whole domain of inorganic chemistry, and knew the sources of the elements in nature first-hand. Their successors must revert to their practise and go direct to nature for their materials, must select them carefully with due regard to what geology teaches as to their age and history, and, before carrying out a single determination, they must analyze their actual raw materials completely, and know exactly what it is they are dealing with. Much of the work on the atomic weight of lead from mixed minerals is useless, for

failure to do this. They must rely more on the agreement, or disagreement, of a great variety of results by methods as different and for materials as different as possible, rather than on the result of a single method pushed to the limit of refinement, for an element provisionally purified by a dealer from quite unknown materials. The preconceived notion, that the results must necessarily agree if the work is well done, must be replaced by a system of cooperation between the workers of the world checking each other's results for the same material. A year ago any one bold enough to publish atomic weight determinations, which were not up to the modern standards of agreement among themselves, would have been regarded as having mistaken his vocation. If these wider ideals are pursued, all the labor that has been lavished in this field, and which now seems to have been so largely wasted, may possibly bear fruit, and where the newer methods fail, far below the narrow belt of elements which it is possible to watch changing, the atomic weight worker may be able to pick up the threads of the great story. No doubt it is writ in full in the natural records preserved by rock and mineral, and the evidence of the atomic weights may be able to carry to a triumphant conclusion the course of elementary evolution, of which as yet only an isolated chapter has been deciphered.

THE STRUCTURE OF THE ATOM

The third line of recent advance, which does much to explain the meaning of the isotopes and the periodic law, starts from Sir Ernest Rutherford's nuclear theory of the atom, which is an attempt to determine the nature of atomic structure, which again is the necessary preliminary to the understanding of the third aspect in which the elements are or may be complex. That uranium and thorium are built up of different isotopes of lead, helium and electrons is now an experimental fact, since they have been proved to change into these constituents. But the questions how they are built up, and what is the nature of the non-radioactive elements, which do not undergo changes, remain unsolved.

Professor Bragg showed in 1905 that the α -particles can traverse the atoms of matter in their path almost as though they were not there. As far as he could tell, and the statement is still true of the vast majority of α -particles colliding with the atoms of matter, the α -particle ploughs its way straight through, pursuing a practically rectilinear course, losing

slightly in kinetic energy at each encounter with an atom, until its velocity is reduced to the point at which it can no longer be detected. From that time, the α -particle became, as it were, a messenger that could penetrate the atom, traverse regions which hitherto had been bolted and barred from human curiosity, and on reemerging could be questioned, as it was questioned, effectively by Rutherford, with regard to what was inside. Sir J. J. Thomson, using the electron as the messenger, had obtained valuable information as to the number of electrons in the atom, but the massive material α -particle alone can disclose the material atom. It was found that, though the vast majority of α -particles reemerge, from their encounters with the atoms, practically in the same direction as they started, suffering only slight hither and thither scattering due to their collisions with the electrons in the atom, a minute proportion of them suffer very large and abrupt changes of direction. Some are swung round, emerging in the opposite to their original direction. The vast majority, that get through all but undeflected, have met nothing in their passage save electrons, 8,000 times lighter than themselves. The few that are violently swung out of their course must have been in collision with an exceedingly massive nucleus in the atom, occupying only an insignificant fraction of its total volume. The atomic volume is the total volume swept out by systems of electrons in orbits of revolution round the nucleus, and beyond these rings or shells guarding the nucleus it is ordinarily impossible to penetrate. The nucleus is regarded by Rutherford as carrying a single concentrated positive charge, equal and opposite to that of the sum of the electrons.

Chemical phenomena deal almost certainly with the outermost system of detachable or valency electrons alone, the loss or gain of which conditions chemical combining power. Light spectra originate probably in the same region, though possibly more systems of electrons than the outermost may contribute, while the X-rays and γ -rays seem to take their rise in a deep-seated ring or shell around the nucleus. But mass phenomena, all but an insignificant fraction, originate in the nucleus.

In the original electrical theory of matter, the whole mass of the atom was attributed to electrons, of which there would have been required nearly 2,000 times the atomic weight in terms of hydrogen as unity. With the more definite determination of this number, and the realization that there were only about half as many as the number representing the atomic weight, it was clear that all but an insignificant fraction of the

mass of the atom was accounted for. In the nuclear hypothesis this mass is concentrated in the exceedingly minute nucleus. The electro-magnetic theory of inertia accounts for the greater mass if the positive charges that make up the nucleus are very much more concentrated than the negative charges which constitute the separate electrons. The experiments on scattering clearly indicated the existence of such a concentrated central positive charge or nucleus.

The mathematical consideration of the results of α -ray scattering, obtained for a large number of different elements, and for different velocities of α -ray, gave further evidence that the number of electrons, and therefore the $+$ charge on the nucleus, is about half the number representing the atomic weight. But van der Broek, reviving an isolated suggestion from a former paper full of suggestions on the periodic law, which were, I think, in every other respect at fault, suggested that closer agreement with the theory would be obtained if the number of electrons in the atom, or the nuclear charge, was the number of the place the element occupied in the periodic table. This is now called the atomic number, that of hydrogen being taken as 1, helium 2, lithium 3, and so on to the end of the table, uranium 92, as we now know. For the light elements, it is practically half the atomic weight; for the heavy elements, rather less than half.

I pointed out this accorded well with the law of radioactive change that had been established to hold over the last thirteen places in the periodic table. This law might be expressed as follows: The expulsion of the α -particle carrying two positive charges lowers the atomic number by two, while the expulsion of the β -particle, carrying a single negative charge, increases it by one. In ignorance of van der Broek's original suggestion, I had, in representing the generalization, shown the last thirteen places as differing by unit by unit in the number of electrons in the atom.

Then followed Moseley's all-embracing advance, showing how from the wave-lengths of the X-rays, characteristic of the elements, this conception explained the whole periodic table. The square roots of the frequency of the characteristic X-rays are proportional to the atomic numbers. The total number of elements existing between uranium and hydrogen could thus be determined, and it was found to be ninety-two, only five of the places being vacant. The "exceptions" to the periodic law, such as argon and potassium, nickel and cobalt, tellurium and iodine, in which an element with higher atomic weight precedes

instead of succeeds one with lower, was confirmed by the determination of the atomic numbers in every case. From now on, this number, which represents the $+$ charge on the nucleus, rather than the atomic weight, becomes the natural constant which determines chemical character, light and X-ray spectra, and, in fact, all the properties of matter, except those that depend directly on the nucleus—mass and weight on the one hand, and radioactive properties on the other.

What, then, were the isotopes on this scheme? Obviously they were elements with the same atomic number, the same *net* charge on the nucleus, but with a differently constituted nucleus. Take the very ordinary sequence in the disintegration series, one α - and two β -rays being successively expelled in any order. Two $+$ and two $-$ charges have been expelled, the *net* charge of the nucleus remains the same, the chemical character and spectrum the same as that of the first parent, but the mass is reduced 4 units because a helium atom, or rather nucleus, has been expelled as an α -particle. The mass depends on the *gross* number of $+$ charges in the nucleus, chemical properties on the difference between the gross numbers of $+$ and $-$ charges. But the radioactive properties depend not only on the gross number of charges but on the constitution of the nucleus. We can have isotopes with identity of atomic weight, as well as of chemical character, which are different in their stability and mode of breaking up. Hence we can infer that this finer degree of isotopy may also exist among the stable elements, in which case it would be completely beyond our present means to detect. But when transmutation becomes possible such a difference would be at once revealed.

The case is not one entirely of academic interest, because it is probable that the reconciliation of the conflicting views of the geologists and chemists, who concluded that lead was not the ultimate product of thorium, and those who by atomic weight demonstrations on the lead have shown that it is, depends probably on this point.

As has long been known, thorium-C, an isotope of bismuth, disintegrates dually. For 35 per cent. of the atoms disintegrating, an α -ray is expelled followed by a β -ray. For the remaining 65 per cent. the β -ray is first expelled and is followed by the α -ray. The two products are both isotopes of lead, and both have the same atomic weight, but they are not the same. More energy is expelled in the changes of the 65 per cent. fraction than in those of the 35 per cent. Unless they are both

completely stable a difference of period of change is to be anticipated.

The same thing is true for radium-C, but here all but a very minute proportion of the atoms disintegrating follow the mode followed by the 65 per cent. in the case of thorium-C. The product in this case, radium-D, which, of course, is also an isotope of lead, with atomic weight 210, is *not* permanently stable, though it has a fairly long period, 24 years. The other product is not known to change further, but then, even if it did, it is in such small quantity that it is doubtful whether the change would have been detected. But, so far as is known, it forms a stable isotope of lead of atomic weight 210, formed in the proportion of only 0.03 per cent. of the whole.

Now the atomic weight evidence merely shows that *one* of the two isotopes of lead formed from thorium is stable enough to accumulate over geological epochs, and it does not necessarily follow that both are. Dr. Arthur Holmes has pointed out to me that the analysis I gave of the Ceylon thorite leads to a curiously anomalous value for the age of the mineral. The quantity of thorium lead per gram of thorium is 0.0062, and this, divided by the rate at which the lead is being produced, 4.72×10^{-11} gram of lead per gram of thorium per year, gives the age as 131 million years. But a Ceylon pitchblende, with uranium 72.88 per cent. and lead 4.65 per cent., and ratio of lead to uranium as 0.064, gives the age as 512 million years. Dr. Holmes regards the two minerals as likely to be of the same age, and the pitchblende to be, of all the Ceylon results, the one most trustworthy for age measurement.

If we suppose that, as in the case of radium-D, the 65 per cent. isotope of lead derived from thorium is *not* stable, and that only the 35 per cent. isotope accumulates, the age of the mineral would be 375 million years, which the geologists are likely to consider much more nearly the truth. But the most interesting point is that, if we take the atomic weight of the lead isotope derived from uranium as 206.0, and that derived from thorium as 208.0, and calculate the atomic weight of the lead in Ceylon thorite, assuming it to consist entirely of uranium lead and of only the 35 per cent. isotope from thorium, we get the value 207.74, which is exactly what I found from the density, and what Professor Hönigschmid determined (207.77).

The question remains, if this is what occurs, what does this unstable lead change into? If an α -particle were expelled mercury would result, or if a β -particle bismuth, two elements of

which I could find no trace in the lead group separated from the whole 20 kilos of mineral. But if an α - and a β -particle were both expelled, the product would be thallium, which is present in amount small but sufficient for chemical as well as spectroscopic characterization. If the process of disintegration does proceed as suggested, it should be possible to trace it, for this particular lead should give a feeble specific α - or β -radiation, in addition, of course, to that due to other lead isotopes. So far it has not been possible to test this. In the meantime, the explanation offered is put forward provisionally as being consistent with all the known evidence.

Looking for a moment in conclusion at the broader aspects of the new ideas of atomic structure, it seems that though a sound basis for further development has been roughed out, almost all the detail remains to be supplied. We have got to know the nucleus, but beyond the fact that it is constituted, in heavy atoms, of nuclei of helium and electrons, nothing is known. Whilst as regards the separate shells or rings of electrons which neutralize its charge and are supposed to surround it, like the shells of an onion, we really know nothing yet at all. The original explanation, in terms of the electron, of the periodicity of properties displayed by the elements, still remains all that has been attempted. We may suppose, as we pass through the successive elements in the table, one more electron is added to the outermost ring for each unit increase in the charge on the nucleus, or atomic number, and that when a certain number, 8 in the early part of the table, 18 later, a complete new stable shell or ring forms, which no longer participates directly in the chemical activities of the atom. Thanks, however, to Moseley's work, this now is not sufficiently precise; for we know the exact number of the elements, and the various atomic numbers at which the remarkable changes, in the nature of the periodicity displayed, occur. Any real knowledge in this field will account not only for the two short initial periods, but also for the curious double periodicity later on, in which the abrupt changes of properties in the neighborhood of the zero family alternate with the gradual changes in the neighborhood of the eighth groups. The extraordinary exception to the principle of the whole scheme presented by the rare-earth elements remains a complete enigma, none the less impressive because, beyond them again in the table, the normal course is resumed and continues to the end.

THE PSYCHOLOGY OF CONVICTION¹

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A NOTABLE contribution of the world convulsion of 1914 and thereafter is to the psychology of conviction. It has been made plain as never before that the strength and directions of men's convictions—authoritatively formulated in loyalties—furnish the decisive motive power of the world's energies. Under this stimulus the need of inquiry into the mental processes that generate and direct convictions becomes increasingly imperative. There can be no question where beginnings lie. The original source of conviction is emotion. In terms of the world's crisis, the *modus vivendi* of nations is still expressible in Mr. Wells's phrase: a "convention between jealousies"; and jealousy is an intense and disturbing emotion. The initial factor in the genesis of conviction is the rivalry between reason and emotion. Convictions are commonly and rightly considered as products of rational consideration; they testify to the distinctive quality of the human mind—conceived and glorified as the instrument of thought, the creator of civilization. In this view the progress of science unfolds as the triumph of reason. Fundamentally it is true that the pattern of conviction is designed and wrought of reason's threads, but not simply so. The design deviates, the workmanship is irregular, as thinking is emotionalized. The wish is father to the thought and breeds true.

The psychology of conviction surveys the play of forces that shape the aims of men, however fine-spun or rough-hewn. The spirit of the survey is analytic; its method utilizes the historic retrospect, studying beliefs that once have lived and flourished, but interprets them by insight into the motives of convictions warmly vital, pragmatically alive, dispensing mingled profit and loss. Living beliefs, cherished and effective, alone supply adequate specimens for study. Their analysis is vivisectional, yet proceeds upon a competent control of established anatomical and physiological relations.

To reach convictions implies an impulse toward thinking; it implies the elementary data of experience and standard

¹ The introductory essay in a volume with this title to appear in 1918.

social environment in which beliefs operate and determine conduct. With these assumed, attention may be focussed at once upon a constant, world-old and ever active factor, which may be called docility, contagion, complacency, imitation, convention—one and all of a nature compact. In this broader view, men's convictions, generation by generation, have been accepted traditionally, as they still are. In every direction of inquiry, beliefs have been embraced and have kept thinking alive, that to later, more enlightened views appear strange, fanciful, and irrational. Most generally, people have believed and continue to believe what they are told and taught to believe. In terms of efficiency this factor in the psychology of conviction dwarfs all others, and may throw them out of perspective. Men of affairs as well as psychologists must continue to reckon with this comprehensive and insistent—whether wise or unwise—imitative-conservative tendency. Its field of operation is wide. In the interpretation of nature and man's place in it, in the intimate communion with animals as quarry, as beast of burden, and as companion, in the regulation of human contacts—of family and tribe, of industry and conquest—in the formulation of myth and the constructions of religion, in the establishment of the social order, the dominant procedure by which uniformity is obtained is that of unquestioning acceptance; as in the practical domain of customs and morals, it is a like-minded tendency to conformity. In regard to these the ordinary man follows responsively, though with growing education more and more responsibly. Penalties are attached to violation, and the taboo rules with universal tyranny. Laws grow in strength and sanction with usage; no phase of thought or action, momentous or trivial, is exempt from the rigidity of the established. The dead hand of the past lays its heavy burden upon man's thinking, permeates the psychology of enlightened as of primitive belief. From a kindred source, in other temper, are derived the lessons of history, the continuity of science, the increasing purposes of men and nations.

By virtue of its comprehensive scope, the factor of conventional conformity may be assumed to be familiar. It occupies the background, constant in its presence, shifting in its setting, against which all other forces, jointly operative, are projected. Similarly important is the fact that in any liberal and modern environment, conformity escapes from a narrow and stereotyped prescription and proscription, and encounters the rivalry of conventions, the contest of opinions, the competitive selection among the loyalties. Congenial beliefs are absorbed, un-

congenial ones shunned, or more truly, fail to enter the orbit of consideration. The conventional combines with and may prevail above the emotional factor in the issue. The gregarious, the social, the cooperative forces draw upon the supporting emotions, and merge the two. Convictions are formed and sustained that are emotionally acceptable and traditionally accepted by a considerable group of one's tribes-folk, neighbors, fellow-citizens; these are institutionally reenforced by the sanction of tradition and authority. But with the systematization of knowledge and the expanding tutelage of science, the play of logical thinking increases notably. In any modern approach the psychology of conviction presents its problems as those of rational rivalry and logical selection, requires the investigation of the complex processes of inclination and plausibility, by which the few are chosen among the many called or calling. It asks why the corner-stone of one man's mental edifice is rejected by the builders of others.

To consider the process of conviction in any measure of detachment from its content is a sterile procedure. The life that is in them, however spiritually or formally sustained, flows in a definitely conditioned body. Lip-service in belief and hollow observance of custom is a common liability. The recital of creeds and rituals with a feeble sense of meaning finds its parallel in the allegiance to institutions, cults, laws, systems, parties, tenets, and practical attitudes with slight and vague appreciation of their basis, either by way of import or justification. For convention and the congeniality of adjustment rule. The part of reason, as likewise of a less explicit intelligence, in the maintenance of convictions that are none the less warmly cherished and embraced, is limited; these limitations form the clues to the understanding of the forces by which beliefs live and move and have their being. The recognizable features through which that being is made manifest appear as the points of attachment of belief; they determine *what* men believe as well as in another phase of their complex psychology they determine *why* men believe.

If this approach is rightly set, the chief determinants of the psychology of conviction, with bearing alike upon process and content, are emotion and convention. Fundamentally beliefs are formed and held because they satisfy, because they minister to some deep psychological craving, or some simpler need or indulgence; equally significant is the sharing of such beliefs with others, which is their indispensable social reenforcement and gives the added value of a conscious adjustment and an acknowledged approval.

Before considering at closer range the nature of the satisfactions that sustain convictions, their psychology should be brought into relation with yet more comprehensive, allied processes. The general formula is supplied by sensibility, which stands as the parent type of the instrument of distinction. As ever, the feeling factor is basic; the elemental distinction is that between pleasure and pain. Recognition promptly enters, and fuses as it extends the lessons of comfort and discomfort, of profit and loss. It widens rapidly to increasing circles of distinctive mental situations, inherent in the indirect responses required of complexly intelligent agents. Eventually distinction becomes an explicit and a logical process—a delineation between truth and error. In simpler situations men feel their way by support of sensibilities; gradually they come to reason their way through the problems that confront them. In any practical modern situation the rational factor is so pervasive, so intricate, alike by nature and tradition, that a prolonged and complex process of education is necessary to fit the individual to cope with it. The place of the keystone in the educative process is held by the structure of science, composed of highly specialized systems of relations, orderly analyses of causes and effects, rigid establishment of principles. These guide and support the most directive convictions of the human mind. In them appear the most adequate products of the logical mind, not detached from psychology but surmounting it. Yet the earlier modes of reaching convictions and the satisfactions attending them, persist; they yield but never with complete surrender to the later discipline.

The varieties of distinctions in the higher reaches of the mind, where lies the psychology of mature and complex convictions, comprise more than the logical ones. The regulations of attitude and action which they serve are commonly distinguished as of three orders: the logical, the moral, the esthetic. In all there is a rightness and a wrongness, a principle of selection which distinguishes alike the decisions and the natures of men. The logically right, the morally right, the aesthetically right is set apart—sharply it may be, with delicacy and uncertainty of distinction more commonly—from the wrong. More specific terms are available. Logically there is the correct and the false, truth and error; morally there is good and bad in conduct and intention; esthetically the standards are more variable, more responsive to condition, but the distinction between good taste and bad taste and their products is no less real. Convictions reflect these several phases of a common human nature.

Conduct is determined by logical, moral, and esthetic convictions. The factors cumulate and interact. The conviction is formulated as one, but embodies logical, moral and esthetic considerations. Now one and now another phase dominates; but the selecting mind is at once and compositely logical, moral and esthetic in its temper, expresses loyalty to each and all. Hence the complexity of the psychology of conviction. The same conclusion—which practically is a regulation of conduct through attitude and belief—is reenforced by logical, moral and esthetic supports. Men share a common allegiance in belief or action upon a somewhat different grouping of motives and reasons.

The practical criterion throughout is conduct. What men do depends upon what they believe, and how they feel; their thoughts and feelings are important because these affect their actions. The common utility is in the regulation of behavior. We thus return to the rôle of conviction as a determiner of conduct. Schooling and experience, book-learning and practical occupations, dealings with men and all manners of social observances and institutions—all of which are regulated by beliefs in the form of traditional explanations—leave as their deposit a logical sense, which acts after the manner of sensibility of the sensory type but with a more complex psychology. The logical sense also follows its type, reflects the stage of culture of the times, the social station, the mental development. It functions by accepting congenial orders of belief and rejecting others, while the very conditions of its acceptances preclude from its horizon orders of conviction beyond its ken. All this is familiar because the like holds of every evolutionary product. The logical sense is the slowest, most laborious, as well as the most precarious of psychological growths. As commonly exercised by the average man, it keeps him fairly safe from crude error so long as he remains on familiar ground. Within these limitations it distinguishes between the true and the false, much as his senses—in turn not so well protected as those of animals—distinguish (though not infallibly) between wholesome and unwholesome food. But to follow the lead of one's mind is a far more intricate matter than to follow one's eyes or one's nose. And similarly of one's moral sense and one's esthetic sense: these select among the alternatives of conduct and preferences of attitude, make their way through situations, and in their exercise according to one's schooling and tradition confer alike logical, moral and esthetic sensibilities and their satisfactions—all of them capable of indefinite expansion. The record of that expansion is in a profound sense the story of civilization.

The moral sense and the esthetic sense are truer to the parent type in that their affective ingredient is strong, and their social dependence marked. Moral convictions and the satisfactions which they bring—and with a different bearing the same is true of esthetic ones—affect the entire psychology of conviction. To neglect in any measure the moral and esthetic moments in the genesis and operation of convictions is to miss the genius of their nature, the source of their strength. Logical convictions and the satisfactions attaching to them are in all respects more derivative and more artificial, belong characteristically to later educational stages. Yet our chief concern is with them, because the latter-day issues which alone adequately illustrate the psychology of conviction as it affects our beliefs and attitudes, are so largely intellectual matters. Our approach to them and our faith in them is in the main a logical one. The disturbances of the even tenor of our logical ways by the strong currents of moral and esthetic emotions and sentiments form a vital part of our problems. They shape daily prejudices no less than the jealousies and unreasoning loyalties that precipitate world's crises.

The profitable pursuit of the psychology of conviction proceeds by the "case" method. Outgrown and discarded beliefs and attitudes, no less than those within our living experience, furnish the data for instructive analysis and suggestive diagnosis. Types of belief demonstrably false, yet once prevalent and commanding the allegiance of a considerable portion of men of fair or superior intelligence, still bring a valuable lesson in the analysis of the appeal which they once made, in the dissection of the motives and arguments which led to their acceptance. As such types of belief are selected from among modern, even contemporary movements, the use of latter-day enlightened criteria is the more justifiable; less allowance need be made for an imperfect logic and for the as yet unexplored regions of the continent of science. In point of fact the illustrations are continuous, with no breach of analogy between ancient credulity and its modern representatives, no abrupt change in the motives or the mechanisms of appeal. With due allowance for the change of outlook and attitude of other days and other ways, there must be considered the parallel changes in the grouping of forces at the focus of each problem considered. This gives the set to the psychology of the several "cases" of conviction; the cases fall into types, and the differentiation of types becomes the psychologist's task.

In clinical metaphor, each "case" requires the study of its

antecedents, of the mode of life, and the individuality of the patient and of the nature of the disease from which he suffers. Patient and disease are at once one and distinct. The study of a "case" of conviction requires knowledge of the antecedents of the problems and its bearings upon human interests, along with a study of the appeal which it makes and the psychology of its adherents. There is the psychology of the conviction as an objective belief, and the psychology of the convinced as a subjective issue. If one assumed a detached point of view, one might separate the strictly logical cases and recognize beliefs accepted upon evidence and applied coldly and consistently. In this view the logical plant—which is the human mind—would accept the crude material in the form of data and turn out the finished product as conclusions. If the result proves to be false, the fault lies in a too ready acceptance of premises or their imperfect manipulation. Such an analysis is bare and formal, literally true but psychologically barren. Yet, as will presently appear, a fair approximation to the type may be selected. The inclination to accept the premises upon the (inadequate) evidence, and the tendency to point the data to the ends reached (prepossession) are as real as the formal logical processes. These tendencies make the psychology of the problem, constitute its character.

"Cases" of this order may readily be summoned from the annals of science. Consider the explanation of fossils. Under a scholastic type of word-learning they were ascribed to a "stone-making force," "a lapidific juice," "seminal air," "tumultuous movement of terrestrial exhalations." To our type of science-drilled mind, all this is the mere husk and shell of explanation, empty verbiage, stale and unprofitable. Yet it is a factor in the psychology of conviction. Dogma and formulæ, formidable words, like popular slogans, help to carry conviction. They are more apt to contribute to obvious fallacy and pretense than to subtle error; but they play their part variably. On the other hand, when the upholders of scriptural literalism accounted for fossils as "sports of nature," as models made by the Creator before he had decided upon the most suitable forms for animals, or as snares hidden by the Almighty to tempt the unorthodox, we are plunged at once into definite prepossessions and allegiances to accepted doctrines which have powerfully affected not only the beliefs but the actions of men. Charges of heresy lurk in the background, and we enter upon the warfare of science² with dogmatically established conviction, how-

² It is in such service that Andrew D. White's "A History of the
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ever fortified. When Voltaire argued (one does know how seriously) that "fossil fishes were the remains of fishes intended for food, but spoiled and thrown away by travellers; that the fossil shells were accidentally dropped by Crusaders and pilgrims returning from the Holy Land," we read the explanation with a strange sense of incongruity between data and conclusion. The true explanation might have appeared strained to Voltaire, because the facts underlying it were so completely out of his ken. Everywhere facts and theories cooperate and determine plausibility. We reach an undisputed "case" of credulity, not merely of weak hypothesis, when we learn of one Beringer who presented long arguments to prove that fossils were "stones of a peculiar sort, hidden by the Author of nature for his own pleasure." It is related that Beringer's students prepared baked-clay fossils of fish, flesh, and fowl—and even specimens with Hebrew and Syriac inscriptions upon them—and buried them in the Herr Professor's favorite digging places. Illustrations of these miraculous fossils were published, with the subsequent attempt of the author to suppress the work when the deception became known. As an individual "case" of credulity the incident would be amusing only; its significance lies in this: that not the inherent improbability of the conclusion by our standards, but the standard of judgment of the convinced scholar is the essential consideration. The tendency to accept the explanation of the origin of fossils (the theory) is congenial to the acceptance of the "finds" as corroborative (the facts). But in the "case" of fossils, however explained, an objective attitude is readily taken. The conviction carries no social or emotional consequences; one's views of fossils has no bearing upon conduct, or at best a most remote one. It sets up no allegiances of a practical order, creates no causes or loyalties, except as the convictions one espouses become extensions of one's personality, defended with the warmth of a cause embraced.

It is the peculiar merit of beliefs concerning our psychological nature, in contrast to the constitution of natural objects like fossils, that they carry such a wide appeal, play so largely among the motives that support vital convictions, while yet *Warfare of Science with Theology*, 1896, has become a classic. Science is neutral in its campaign. It necessarily regards dogma as its enemy; it respects the province of religion when the latter refrains from an invasion of occupied territory. The tremendous struggle of the evolutionary position to gain a foothold in the nineteenth century is an adequate example of the varied prejudices which scientific argument may encounter in enlightened times.

patterned after the manner of scientific conclusions. An interesting group of beliefs relates to the interpretation of human types and differences. The ancient doctrine of temperaments, explaining the psychological types of men by the dominance of blood (sanguine), black bile (melancholic), yellow bile (choleric), and phlegm (phlegmatic), is as purely fictitious and as baseless as the cited views of the origin of fossils; but it persisted with remarkable tenacity and gave rise to a varied progeny of speculations that in turn dominated the convictions and the practises of men. The doctrine of the four temperaments was incorporated in the "humoral" system of medicine. From Hippocrates to Harvey, diseases were diagnosed and patients treated in terms of the "hot" and the "dry," the "cold" and the "moist," with most fantastic elaborations. Chills and fevers, parchings and perspirations, flushing and pallor, confirmed the findings; and the recovery of the patient—by the assistance of nature or in spite of the resistance to nature—proved the value of the system and established the prestige of the practitioner. The explanation of disease (theory) and the cure of ills (practise) form such a powerful motive to thought and action that the entire armament of the mind's powers—scientific and imaginative—was brought to bear upon the problem. The most ambitious of such constructions was the medical application of astrology, seeking the fate of men in the positions of the heavenly bodies. Medicines were concocted and administered with reference to the position of sun, moon and stars; elaborate correspondences were set up connecting the mineral, the vegetable, the animal kingdoms and the cosmic systems with the fates of men and the cure of ills that flesh is heir to. Disease is but part of man's fate. The prediction of the future, the control of fortune, the detection of talents—all combine and proceed upon the same flimsy logic and consoling psychology. The horoscope summarizes the issue astrologically as alchemy physiognomy, palmistry, phrenology and their like illustrate the persistence of the notions and the imaginative constructions by which they were satisfied. All these vagaries of the human mind in the realm of conviction—vagaries to us, but serious beliefs to former generations—embody a common psychological factor, that of finding what one seeks, which is vital to the understanding of each and all. Also central to their psychology is the tendency of the thought to shape the issue—the peculiar and elusive sense in which thinking aids and induces the result. In the treatment of diseases, this becomes "mind-cure"—the faith that facilitates

as well as the prejudice that blinds. The possession of this key to the situation—like the knowledge of the true nature of fossils—exposes the irrelevance and falsity of the several wild if shrewd guesses and proofs; but unlike the “case” of fossils, the motives contributory to convictions in regard to human nature and the control of human fate continue in subtle and complex form to shape current views, orthodox and unorthodox alike. We are still subject to disturbing influences in the psychology of our convictions, in the interpretation of our own psychology; the establishment of the logic of science in these realms is still imperfect by virtue of the same tendencies—admittedly far better disciplined—that gave currency to beliefs that seem to us preposterous in temper, absurd in evidence. Thus in retrospect the dual lesson bearing upon the psychology of conviction appears: first, that every advance in understanding is a step forward in logic, in the standards of evidence and the rigidity of conclusions, in the conceptions of plausibility and the discipline of the mind; second, that the forces inclining to belief persist, however altered their perspective, and continue to make the attainment of reasonable convictions and the consistent direction of conduct through them, a difficult and delicate task—the art of intellectual living. Wisdom is the name for the exercise of the logical function, with due recognition of the assets and liabilities of an ancient and fallible human psychology.

Such considerations make it pertinent to look upon persistences or revivals of beliefs continuing the older patterns of conviction, as survivals—never simple, often intricately disguised. Along with the older loyalties they incorporate the newer ones; particularly, they profess and in a measure maintain an adherence to high-grade logical standards. Their defection, however, is as commonly and as essentially a reversion to older psychological habits of belief as to a weakness in logical manipulation. Such “cases” of survival are most varied, indeed individual in composition. Interesting examples may be found in that wide domain already surveyed, belonging to psychology in a double sense: the one, is that the content of the belief relates to the conceptions of thinking and the views of our psychic nature; the other, is that the tendencies shaping belief in this realm are so characteristic of the “conviction” phase of our psychology. One of these “cases” and the most typical is the survival and revival of the belief in the possession of powers by some individuals in defiance or transcendence of the established laws and limitations of human endowment.

So characteristically psychological is this conviction that the phenomena associated with it have received the name of "psychical research"—a term irrelevant or misleading, but harmless if accepted as a convenient phrase. As here considered there is no choice but to consider the belief-tendency thus displayed as an inclination toward the supernatural. This merits detailed analysis; its "cases" are difficult, sometimes baffling. For the belief persists in minds thoroughly loyal to scientific ideals in other realms. The "cases" contribute a further factor to the psychology of conviction, and raise the interesting question of consistency. They suggest the existence of reserved areas of belief, more or less exempt from the limitations of logic, where the satisfactions of belief may be more freely sought and accepted without logical compunctions. Such indulgences are more appropriately considered under the personal phases of belief; but they contribute essentially to the convictions that keep alive the "proofs" of telepathy as of other modes of mental communication unrecognized by psychology, and the evidence of survival after death at the hands or mouths of mediums. The logical interest lies in the elaborate technique which such convictions have developed in support of the hypothesis, and the continued vitality of the belief despite repeated exposures of fraud in the accumulation of evidence, and woeful defects in logic in the arguments. Much of the belief in the supernatural is based upon the conviction that the facts cannot be otherwise explained, that deception is impossible. Such assumption in turn has its reasons; they lie in the will to believe and the gross underestimation of what can be done by deliberate or subconscious deception.

It is fortunate that "cases" of belief in the supernatural occasionally venture into the domain of the physical where their pretenses invite disclosure. Such detective service is in no way obligatory upon physicists and psychologists, even though their domain is intruded upon and their title challenged; it may be accepted as an obligation in the interests of social sanity which any competent protagonist of science may properly undertake. Such is the "case" of Paladino. Reduced to barest outline, in the presence of Eusapia Paladino—a Neapolitan woman of peasant status—tables moved, curtains blew to and fro, tambourines rattled, while seemingly her hands and feet were controlled. Incidentally the large compensations for witnessing the performance filled her purse. All this exploitation is commonplace and sordid. Upon the inability of men prominent in one or another scientific field to detect how it was done, is

reared the hypothesis that these occurrences demonstrate supernatural powers. When it is shown by counter-plotting, that the "medium" disengages one foot and lifts the table on her toes, the entire logical construction tumbles ignominiously; but the "psychology of conviction" of the case, like the moral, remains. The relation between premises and conclusion before the convincing disclosure, and the tendency to build upon them the belief in the supernatural, are just the same as before. The factors in the case are the enormous influence of the prestige of the sponsors for a performance that without it would attract slight attention; the weak logical sense that interprets the inability to detect how a thing is done as strengthening an otherwise unsupported hypothesis; but last as first, the tendency below the surface to accept the supernatural hypothesis is responsible for the "case."

This group of survivals, occupying the middle ground between old-time credulity and present-day controversies, is a fairly extensive one. It may be extended to include instances in which older conceptions are applied to newer problems with a weak sense of their incongruity. Such is the problem of animal intelligence. The inclination to ascribe to animals remarkable powers of mind is more creditable to human charity than to human thought; it is more a matter of sentiment than of logic. The science that speaks with authority on this issue is psychology; and we have already seen how difficult it has been for man to gain a critical knowledge of his own endowment and its workings, and the same holds of the minds of animals. Psychology has established how slow and laborious are the steps by which a decent logical control of data has been secured. The process is illustrated in the education of every child. Yet animal prodigies are placed on exhibition, and admiring audiences accept simple trick-performances as evidences of calculating horses, talking dogs, and educated animal geniuses. Learned books are written to prove that neither fraud nor self-deception has entered; the interest in the matter is so disturbing that commissions, on which professors of psychology serve, must be appointed to allay the mental unrest. Once more the discrepancy between performance and conviction is flagrant. A horse paws with his right fore-foot (as horses do), and is taught to continue to do so until he perceives a signal to stop. The performer advertises that the horse adds, subtracts, divides, extracts square-roots, counts, tells people's ages, knows grammatical construction, and what not. (It should be added that a bright horse or dog is so keenly observant that owners of such

animals may believe in the powers with the sincerity of self-deception.) The entire "case" would be ludicrous did it not furnish so neat an example of how conviction creates miracles, how readily prepossessions engender credulity, how inadequate is the popular notion of the foundation of mental processes which all enjoy, and how weak may be the logical sense that alone can protect against the acceptance of such performances at their alleged value. Even in the twentieth century the case of "mathematical horses" makes a distinct contribution to the psychology of conviction.

By this devious route we come to the present-day arena of contention in which opposing convictions, all professing a common loyalty to logical (or it may be to moral or esthetic) principles, defend opposite conclusions, favor antagonistic policies, bid for support as rivals, and array men in parties and factions, in schools and sects, as well as in hostile camps and campaigns. The controversial area of the psychology of conviction is a close neighbor to those considered; their boundaries touch and overlap. The older motives reappear with chastened mien; the analysis proceeds more considerably of subtle error and more delicate bias. Selection of "cases" is difficult by embarrassment of riches; for here lies the source of the saying: so many men, so many minds. The desire is to tap the controversial current at its richest flow, to illustrate the variety of its contributory streams, the many sources of its hidden springs. As a triad of such issues, sufficiently typical and distinct, may be selected the "case" of indulgence, the "case" of the feminine mind, the "case" of militarism and pacifism. In the one issue there stand embattled the prohibitionists and those who favor a sane, even an indulgent regulation of such practices (admittedly a serious evil in excess) as the use of tobacco and alcohol; in the next, the feminists contending for a nullification of the restrictions in the movements and careers of women, minimizing the differences of the sexes and their inherent consequences, as opposed to those who believe these differences to be vital, comprehensive and established; in the last the most intensely partisan arraignment by believers in peace of the horror, waste and unreason of war, by believers in war of the blindness, sentimentalism and visionary impracticality of pacifists. The fact which the psychology of "controversial" convictions faces is that in the presence of the same data and comparable schooling and environments, men reach deviating and opposite conclusions. Each party believes strongly that he has definitely proved his case. Yet it cannot be doubted that in the

main the minds thus in disagreement are fairly similar problem-solving instruments. They are not identical in nature nor mechanical in procedure. The human mind is by no means a loom receiving raw material, and with the pattern once set turning out a uniform product. For simple mathematical processes the formula holds; it makes no difference what mind performs the calculation. In controversial issues and practical policies it makes the greatest difference what manner of mind receives, elaborates, considers, and concludes. The individual factor dominates and yet holds true to type. Differences of opinion as of policy and taste are not chaotic or capricious or arbitrary. Despite all fluctuations, reason in well poised minds is an orderly procedure, and principles endure. The temptations to depart from such order are precisely the points of interest in the controversial phases of the psychology of conviction.

In explanation it is familiar that data known to one mind may be unknown to another, and that the importance attached to one group of data may differ in one mind and another. But behind all this and determining it is the predilection that selects and gives weight to groups of data of favorable bearing, inclines the interpretation to a predetermined bent, and reaches a conclusion more by reenforcement of an anticipation than by any progressive step; which means that it is not the force of evidence but the magnetism of conclusions that attracts. And this in turn is true because such specific predilections in regard to one issue or another are themselves the issue of a general perspective—compositely logical, moral, esthetic and practical—which determines the values of experience and arguments, that determine the set of one's convictions. We may call this character, we may call it a point of view or *Weltanschauung*, and bear in mind that this exists as really though in less finished and articulate form, for the unsophisticated as for the learned mind. Indeed one of the marked differences between them is the relative immunity of the disciplined mind to the disturbances of emotional predilection and subconscious prejudice. Yet the best schooled minds take their stand determinedly, with staunch convictions, claiming no exemption from human bias, but making allowance in their well-balanced judgments for the psychology of conviction as operative in themselves and in the world in which their influence makes itself felt. Any more intimate analysis requires the concreteness of a specific argument with all its ramifications and bearings, its traditional relations to custom and opinion. By considering the series of

steps by which one arrays one's self on one side or the other of such controversies as those concerning prohibition, feminism, and militarism, one will realize the manner in which facts, arguments, experience, predilection and one's general outlook upon the values and precepts of life, cooperate in the formation of positions, attitudes, loyalties—all of a practical order. In this estimate one must make large allowance for the persistent forces of convention, tradition, and imitation as individually operative; for these spread and fix conviction quite as they disseminate other habits of reaction; and parallel in importance remains the factor of a personal, emotional, temperamental congruity. Furthermore, in controversial questions where so commonly the data are imperfectly known and the arguments inadequately understood, convictions none the less proceed as confidently—possibly more confidently—under these limitations as in their absence. For doubt is an unpleasant state of mind, and the reaching of a decision and the taking of sides constitutes an indispensable type of satisfaction.³

We turn to the personal aspect of conviction, not as a novel factor (for everything is personal in the sense that there are no beliefs, only believers), but as a special emphasis. What men believe and why men believe converge in the satisfaction of belief—which is a personal reaction. The conviction once attained in conformity with one's psychology yields its satisfaction in the removal of doubt, the support of conduct, the consolation of faith, the guidance by principles, the consistency of a system or point of view, and adds to these the contented feeling of adjustment. Such are the common functions of creed, sect, party, principle, code, custom, loyalties. The act of subscription, allegiance, enlistment settles matters. Patriot-

³ The incompleteness of this analysis of the psychology of controversy is obvious. It is intended only to prepare for the analysis of concrete cases; for the "case" method is the most instructive in this domain. Two possible factors are ignored: the one the element of intentional deception or the distortion of a biased interest; and the other the allied element of hypocrisy and inconsistency. These receive some attention under the consideration of the personal phases of belief; yet they play a specific part in controversial issues. In illustration the attitude toward education as a means of fitting the mind to play its proper part in life offers a pertinent example. The ordinary democratic view professes a cordial support of education and an admiration of the products of the trained mind. But actually it distrusts scholarship and deprives it of a reasonable share in social control. Such an attitude is one of suspicion masked by avowed confidence. It is an excellent and by no means isolated instance of the inconsistency between theory and practice, between profession and performance. Since most controversies have practical issues, this phase of the matter is often of decided consequence.

ism may be cited as a comprehensive expression of the issue and raises the question in how far one's patriotism is a sentiment or a conviction. An American can with difficulty conceive his allegiance of country as otherwise disposed. Yet he knows that millions of his fellow-citizens of like nature with himself profess an adopted allegiance, while a divided one (neglecting the complexities of the great war) is wholly compatible with a proper consistency of purpose and attitude. All this is fairly well understood, for it operates close to the surface of our deliberations, and our articulate sentiments. Following this trend, one might conclude that the desirable order of satisfaction is as obtainable from one type of belief as from another. Loyalty is everywhere similarly conditioned; the sense of attachment is the main thing and may be inculcated as readily upon the platform of absolute autocracy in government as of the freest democracy. It is not in such types of conviction that the distinctively personal factor is conspicuous; quite the contrary, it is in such larger loyalties—all supported by convictions—that the individual merges with the crowd, with the collective mass, and even surrenders to it. This, however, does not detract from the personal intensity of the convictions thus formed, nor from their efficiency. Upon the sentiment of patriotism, and the conviction that one's country is in the right, is based the integrity of nations, even to the supreme sacrifice of the soldier. Defection in this attitude may mean mutiny and treason. It is a sobering reflection that the ultimate bond of nations, as everywhere the unity of a collective purpose, rests upon the integrity of the personal convictions of those enlisted. This is the fundamental reality and gives to the study of conviction its unique importance. That such personal intensity of conviction may come from any or many sources, must ever be borne in mind.

It is in the more individual affiliations and in the narrower circle of one's loyalties that the personal element appears in stronger relief. There is one system of psychology, with bearings upon the genesis and nature of conviction, that is entitled to precedence in our considerations. The psychology of Freud is reared upon the relation between motive and belief, upon the wish as father to the thought. In broader outline the Freudian system explores among the subterranean roots of motives to discover the promptings of thought and action. It emphasizes the subconscious; and it builds upon a group of mechanisms, by which the apparent, superficial stream of thinking is brought in relation with the deeper, hidden sources of its flow. To no

mental product does the system apply more intimately than to convictions.⁴ For the first and last things in the Freudian psychology are motives; and the clue to conviction (beyond the realm of undisputed reason) is motive. In the view of Freud the mental life is a struggle—a conflict between what is, what we are and must do, and how we should like to have things, what we should like to be and do. So imagination enters to bridge the gap, and the fictitious pleasures of day-dreaming and of conclusions not untouched by delusion yield their satisfactions. Truly rationalization enters, and we justify our beliefs and acts by reasonings to conceal their real motives in emotion and desire. The mechanisms of thought are mechanisms of concealment—a psychological *camouflage*; reason masks emotion, in that the acknowledgment of the emotion is unpleasant or otherwise tabooed, while the appeal to reason is accredited and creditable. The masking devices are varied, some dramatic, others shrewd, others subtle. The most typical is the device of compensation. Lacking one satisfaction we minimize its loss by setting up another in its place. A salient example is that of a man of checkered and uncertain career, in all essential respects a failure in life, despite conspicuous talents, who in announcing the subject of his personal reminiscences as a platform topic chose the title: "How I Achieved Success." That title is a Freudian confession of failure, disguised to the self that makes it. Similarly, if the German mind is prepared to stand by its Austrian (Freudian) ally in the psychological field, the Teutonic insistence upon the superiority of German "Kultur" is to be interpreted as a Freudian confession of a sense of lack, the inability to achieve that delicate appreciation of the values of life that is characteristic of the French, or the well poised directive capacity and clean-cut analysis of the English mind. The compensation is the gigantic and immodest delusion of superiority. Suspicion or accusation is often of the same nature, imputing to others motives present in oneself, but disowned. The same applies to apology in that it implies a self-accusation: *qui s'excuse s'accuse*. The conception of convictions as formed or supported by this mech-

⁴ The parallel applications of equal importance are to the free material of dreams, reveries, imaginative excursions (also to seemingly accidental lapses, like forgetting and mislaying) and to impulsive, aberrant conduct. All these orders of expression lose their detached character when supplied with the clue of motive. It is not necessary to accept the extreme Freudian interpretation, particularly the reference of all these mental products to the motives of sex. The Freudian view is entitled to respectful consideration; it has proved suggestive in many directions.

anism of emotional transfer—in consolation or compensation—yields a restricted but authentic application of the Freudian principles. The Freudian mechanisms apply more fully to expressions of stronger, more original emotional tone—like the instinct of motherhood lacking its authentic outlet and seeking substitutes in the mothering of pets or causes; yet like these, convictions serve as a temperamental satisfaction by employment of similar devices. Other common Freudian factors may be noted. There is over-determination, overdoing—in excess of recoil, through some internal resistance or scruple, swinging far to the opposite extreme. The characteristically Freudian aspect of the issue is that the impulse to the extreme is felt, but the motive source remains subconscious; yet it operates and projects from its depths a sense of trouble and difficulty. Conviction may be held waveringly yet longingly, shiftingly in successive devotion to fads and “isms.”

The “conviction” aspect of the conflict is a struggle for consistency as well as for contentment, which in its ripeness aims at the harmony of one’s beliefs and conduct. Such a consistent whole is a personality, many sided but single minded. Thus in tracing the orbit of conviction, we constantly return to the emotional motive—an emotion close to will. The common name for this is desire, the Freudian *wish*. In so far as the Freudian diagnosis applies, it is the unfulfilled wish, the thwarted desire that shapes the true motive of conviction; it operates in so far as the belief is by nature or adoption warmly cherished, with a deep personal absorption; it is peculiarly applicable to extreme semi-pathological temperaments, in which the processes are emotionally intensified. But a more common Freudian mechanism peculiarly applicable to the genesis and support of convictions is rationalization, which is the justification of belief to reason. We actually believe by virtue of a trend anchored in personal desire, and have recourse to reason to mask this source—to clothe a personal conviction in more presentable garb. Accepting the motive as a “reason,” we believe for one reason and defend conviction for another; such is the Freudian defensive and self-deceptive mechanism. In some measure the conviction may be unreasonable, yet it secures and maintains its hold by conformity to authentic psychological processes.

The mechanisms thus described in Freudian manner have been otherwise and previously recognized; the Freudian setting adds to their illumination and to their relation to our general psychology. In application to conviction, we must proceed

more delicately, with discerning allowance for the type of conviction involved. We recognize that we are committed to a certain pride in our rationality; we make claim to be reasonable beings; and for this end our dress-parade selves argue and defend as well as ignore and conceal. By quite the same route in practical matters, we admit that our interests come to determine our positions; and yet know that scientific judgments must be disinterested and unprejudiced.

Intense conviction obscures vision; yet enthusiastic interest opens our eyes; we must accept the liabilities along with the assets of our own psychology. In Freudian aspect beliefs avoid contact with reality by surrounding themselves with a defensive smoke-cloud of security; in scientific employment, hypothesis and speculations extend the study of reality, alike in detail and in scope. Neither the one nor the other issue is necessarily involved nor readily avoided. In consequence the consistency of the varied convictions of all sorts and conditions of men on all sorts and conditions of questions is a partial one. An equal consistency in all one's varied interests is an attainable but rare ideal, possibly not even a desirable one. A common form of inconsistency suggests the hypotheses of reserved areas of conviction in which predilection may disport itself in freedom from the restraints of too rigid a logic. It is possible that a man of science may be cautious and logical in his special domain, but in matters outside of it in which a personal bias enters, may be uncritical, even credulous, and accept or propose arguments fallacious or weak. Such defection constitutes the personal factor in the prevalence of the "survival" types of conviction already reviewed. The hypotheses of "reserved areas of belief" applies characteristically to the spiritualistic phase of "psychical research"—that is the acceptance of evidence of the communication by the departed through mediums; it applies particularly to the "case" of Paladino, while yet this "case" is made by the prestige attaching to the scientific reputation of her sponsors. The hypothesis applies sporadically through the several incidents that have attended the renaissance of spiritualism since 1850. Inclination to accept the spiritualistic belief is the main factor; the evidence plays a secondary part. Those responsible for such evidence contribute to the psychology of deception,⁵ as the deceived contribute to the psychology

⁵ I have considered these problems in an earlier volume: "Fact and Fable in Psychology" (1900), particularly the first five studies. Accordingly the types of belief in which credulity, intentional deception, and weakness of logical sense play the leading parts in the dissemination of

of credulity. This holds for the vast majority of believers; but for the few and the leaders of the movement, the conviction suggests the operation of a reserved area of belief. Whether the reservation is due to a Freudian complex is an individual question.

There is a further aspect of such allegiances: namely, the attraction which a belief excites by its very departure from rationality; the tendency is due to the lure of the obscure. Its most philosophic expression is mysticism. But the cooperation of other factors is apparent. Such occult and irregular beliefs grow by contagion; they grow by prestige; they grow by a congenial selection of adherents; and a factor in the last contribution is the satisfaction of clinging to the esoteric, of belonging to a different order, a less conventional cult than that which secures the adherence of the ordinary man. Even radicalism makes its converts by some measure of such appeal. But simple credulity, or logical weakness is never absent, and constitutes a personal factor in the issue. Consider such a belief as that in phrenology, which is fairly modern and continues with revivals to recent times. What the attraction of such a belief may once have been or how it continues to exist, albeit with lowered caste, it is not easy to determine. Lack of scientific training may be the chief factor in its spread; but each such belief leaves the problem of how this particular belief selects its recruits. The same is true of homeopathy. In both cases those who follow the system may have difficulty in describing either the basis of the principles, or their own adherence to them. Such excursions into the history of personal attachments might add to the psychology of conviction; but their pursuit leaves the central problem of the present study. Obviously such beliefs linger with a low vitality, and the change of their clientele suggests the degeneration of a city neighborhood when a residential district loses its prestige.

Continuing in the direction of the irregular, we come to beliefs that may properly be called pathological. Such beliefs are so strikingly individual that they are ordinarily not shared by others. They are called delusions and are characteristic of insanity in its various forms. Here the personal factor reaches its maximum scope. Such delusions may likewise appear as Freudian compensations; their modes of rationalization are so irregular that therein is recognized the mental aberration which false beliefs, are not emphasized in the present consideration. The portions of the volume just referred to may be accepted as an amplification of this position, in terms of analysis and illustration.

represents the extreme issue of personal conviction in its deviation from logical standards. The manner of reaching one's convictions as well as the convictions reached thus become a criterion of one's sanity. Such (delusional) beliefs do not affect others; nor are they taken seriously. The rare "case" in which an individual belief of this type plays a part in a system of wide acceptance in modern times is supplied by the case of Mrs. Eddy. Her personal delusion of a "malicious animal magnetism" runs through "Christian Science" so far as that system reflects her life-history. She accused disciples who had escaped from her influence, of this peculiar form of sorcery (mental poisoning, she called it), and took all sorts of precautions to avoid its dire effect. Naturally the great mass of her followers ignored this strange belief; yet their attitude to the tenets promulgated by Mother Eddy, if consistent, implies a subscription to this belief also. The inclusion of Mrs. Eddy's belief in malicious animal magnetism is accordingly pertinent to the personal and pathological aspects of conviction.

The practical issue of the operation of these several cooperating and conflicting factors is the tolerance of all manners of convictions and compromises and makeshifts in the mental household. No one is completely logical, and no one is devoid of the logical impulse and a certain logical consistency. But the psychological trend runs more deeply, more pervasively. Conviction appears as a compromise of logic with psychology. The solution of our problems depends not alone on the discovery of truth, but on the control of the means of securing its acceptance. To gain for beliefs their proper recognition amid the rivalry of convictions and of the forces sustaining them, is an art. The slowness and laboriousness of human progress is a direct consequence of these conditions and limitations of the human mind. The acceptance of new truth meets with all sorts of oppositions and resistances, which though collectively expressed are individually experienced. The conflicts of men, as of nations, take place in the arena of personal conviction. Purposes, policies, jealousies, ambitions, sentiments converge in the formulation of a conviction, which may be as simple as a slogan and as complex as a destiny.

Viewed retrospectively, the greatest triumph of the human mind was the gradual removal of large areas of belief from the influence of the psychology of conviction. Scientifically established truth came to proceed objectively, undisturbed by interest in the outcome of inquiry and determined by the sanction of verification. The disestablishment of the anthropocen-

tric view of the universe culminated in the removal of human desire from its place of dominion in the formation of belief. The process is but partially accomplished even in disciplined minds, and for the great masses of men plays a subordinate part in the scheme of their lives. Moreover, the existence of so many controversial issues, in which conclusions are far from clear and yet action is demanded by condition, imposes the exercise of judgment upon mixed motives of logical loyalty and psychological appeal. For all these reasons the understanding of the stream of influences that play upon the genesis and shift of conviction is a permanent occupation of the psychologist. The obligation to seek control of human convictions through a study of their nature applies with peculiar force to twentieth-century conditions in which a sentiment of democracy prevails; for democracy imposes or encourages the consideration of convictions by inviting adherence to parties and confirming the verdict of the ballot. Democratic forces operate far beyond the political realm; there is hardly a page of the daily press that does not make an appeal to men's actions by prevailing upon their convictions. Rival newspapers bring to their selected clientele the reenforcement of convictions already espoused. Towering above all other issues are the set of convictions that have arrayed the dominant nations of the world in a colossal life-and-death-struggle. The world-war is a war of convictions, tragically consigned to the ordeal of a scientific armament of destruction; and the decision, however reached, will establish one set of convictions in the minds of men, and depose its rivals. Once the normal relations of men and nations again prevail, we shall be able to look back upon the struggle with the saner logic of a scientific judgment. While the awful struggle continues and in its progressive steps, we become the passionately interested witnesses of the play of psychological forces on the largest scale that has ever been enacted. Parallel with the clash of armament is the process of conviction; both will participate, and presumably the latter with greater influence, in the negotiations of peace—in the restoration of a normal outlook upon the values of life and their control by sane convictions.

REPTILES AS FOOD

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IN these days when "conservation" is a byword and every man, woman and child is, or ought to be, thinking of the food problem, it may be of interest to notice the extent to which the comparatively small class of animals, the reptiles, are used as food, and to call attention to one or two ways in which they might be more extensively used.

For the sake of convenience, the class will be divided into the four old orders: the Chelonia, or turtles and terrapins; the Lacertilia, or lizards; the Ophidia, or serpents; and the Crocodylia, or crocodiles and alligators. Of these the first is the most important and will be first discussed.

Turtles are used for food over practically the entire world, but it is said their flesh is forbidden to Mohammedans, and is abhorred by certain Greeks.

Nearly, if not all, species may be eaten, but there is, of course, much difference in the quality of the flesh, and Surface states that during a strike of miners in eastern Pennsylvania many of them were made sick by eating turtles, supposedly the box tortoise, so that the common idea that this form is inedible, at least at certain seasons, is probably correct. There are also a few species whose offensive odor makes them undesirable as food. It is said that even the flesh of the green turtle, about to be described, is poisonous at certain seasons of the year in some countries where it is found.

THE GREEN TURTLE, *Chelone mydas*

This is, perhaps, the most important of the turtles as an article of food; it is an important article of commerce, and is an important part of the diet of some of the tropical peoples. It is found in tropical and semi-tropical seas throughout the world, and may reach a weight of five hundred pounds, though these huge ones, are not so good for food; those found in markets usually weigh from fifty to seventy-five pounds, and sell for about 35 cents per pound. The name has been given because of the green color of the flesh. Jamaica was formerly

and perhaps still is, one of the chief centers for the green turtle industry; Key West has also been an important center. In one year fifteen thousand animals were received into England, besides a large amount of dried meat in cans, the meat for canning being cut into strips and dried in the sun, where it acquires almost the consistency of glue and requires long soaking in water before it is fit for food. As in many other turtles, the oil may be extracted and used for culinary purposes in place of butter or olive oil.

In markets these turtles are kept lying on their backs not only to keep them from escaping, but because, being adapted to life in the water, they would not be able to breathe if laid upon a hard surface, right side up; their plastron is not firm like that of a land form, and the weight of the animal when not supported by the surrounding water so compresses the internal organs that suffocation is produced. The flesh may be cooked in various ways and is said to be very digestible.

The green turtle lays from two hundred to three hundred leathery-shelled eggs that are said to be more nutritious than hen's eggs; a dozen of them may be eaten at once. The eggs, which are carefully buried and concealed by the female, are found by prodding in the sand, along the shore, with a sharp stick.

Along the Amazon and Orinoco rivers the eggs of various turtles form a very important article of food; they are preserved by rolling and packing in salt, and in other ways. A kind of oil, much esteemed by the natives, is made from them, preserved in jars, and used like butter. The collection of such enormous numbers of eggs has nearly exterminated the apparently limitless numbers of turtles in some places.

The eggs of many of our common fresh-water turtles are good as food if taken from the animal or obtained soon enough after being laid.

THE LOGGERHEAD TURTLE, *Thalassochelys caretta*

This is another large, marine form, somewhat similar to the preceding, that is sometimes found in the markets, though it is of much less value.

THE DIAMOND-BACK TERRAPIN, *Malacoclemmys palustris*

This species is supposed to be the most delectable of all the turtles. It is a comparatively small animal, rarely reaching a length of ten inches, that is found in the salt marshes of our coast, from Massachusetts to Texas, those of Chesapeake Bay being, perhaps, the most famous. It has been named because

of the angular areas made by the concentric lines on the carapace.

They hibernate by burying themselves in the mud along the shore, whence they are tracked and dug out for sale in the markets. Their rarity and comparatively small size, combined with their unusual flavor, cause these turtles to be among the most expensive of our food products. A single animal of seven inches' length is worth about six dollars, and the price increases at the rate of about one dollar for each additional half inch in length; a seven-inch specimen weighs about four pounds. At such prices it would seem highly profitable to raise these turtles under artificial conditions. The experiment has been and is still being tried, but the slow growth of the animals and the small number of eggs produced each year make the enterprise a doubtful one from a financial point of view.

THE COMMON SNAPPING TURTLE, *Ghelydra serpentina*

This familiar chelonian inhabits ponds and slow-running streams of the United States east of the Rockies. It sometimes weighs as much as forty pounds and is named from its habit of snapping at any annoying object with such vigor that a human finger may be amputated by a moderate-sized specimen. They are sold in large numbers in some of the greater cities and bring about ten cents a pound.

The food of the snapper consists of all sorts of animal matter, and it is sometimes very destructive to ducks and other water fowl, destroying entire broods of the young birds. Should the snapper become a pest in the duck pond, it may be caught, according to Surface, by baiting a strong fish-hook with a piece of tainted meat and tying the line to a slender stake or tree that will bend when the turtle pulls. The hook must be fastened to the line by a length of slender wire, so that the turtle can not bite off the hook and escape.

In its feeding habits, then, it is probable that the snapper is more harmful than beneficial; the birds, frogs and fish it destroys more than making up for the insects and other pests that it eats.

THE SOFT-SHELLED TURTLES, *Genus Trionyx*

There are several species of soft-shelled turtles in the United States, and, while they are differently named by different writers, they may all be recognized by the soft, leathery character of the shell and by the proboscis-like snout. They are thought by some to be the most palatable of all our turtles

with the exception of the diamond-back, and, as a large specimen may reach a length of eighteen inches, they furnish, in some sections, quite a valuable supply of food.

Their omnivorous habits make it difficult to determine their economic importance in this regard. It is said they are very destructive to fish and water-fowl in some regions; on the other hand, they may do an important work as scavengers and as destroyers of insects. Many of them are savage in disposition and their jaws are capable of inflicting ugly wounds. Most of them are strictly aquatic in habits, being found in ponds and muddy streams, which they seldom leave.

The fresh-water turtles that are used for food or for scientific purposes are captured in various ways. Many of them are taken, sometimes scores in a day, by digging them out of the mud or sand in the bottom or along the shores of the ponds or streams in which they live. At the approach of winter they bury themselves in these places and hibernate until spring. With a pointed and barbed rod the hunter prods into the mud and on feeling a turtle pulls it up with the rod. Turtles are also caught on a line baited with meat, as mentioned above. In the case of the soft-shelled turtle the meat is kept near the surface by a cork. Wire traps, with funnel-shaped entrances like fish traps, are often used and are baited with ears of corn that become sour and attract the turtles. Such traps must be examined at moderately frequent intervals or the turtles may drown. The collection of fresh-water turtles, in some sections, is quite an important industry.

The lizards are important to mankind chiefly as destroyers of insects, but a few of them are used as food in tropical and semi-tropical lands. Of these the giant Iguanas, reaching a length of six feet or more, are the most important. The flesh of these lizards is said to be of a delicious flavor, resembling chicken. In the Bahamas the lizards were formerly one of the most important articles of food; they were hunted with dogs, and kept in captivity until wanted. They have been hunted almost to the point of extermination, in some localities. The way in which the early Spaniards overcame their repugnance to these ugly reptiles is told by Peter Martyn thus: "These serpentes are lyke unto crocodiles, saving in bygness; they call them guanas. Unto that day none of oure men durste adventure to taste them, by reason of theyre horrible deformitie and lothesomnes. Yet the Adlantado being entysed by the pleasantnes of the king's sister Anacaona, determined to taste the serpentes. But when he felte the flesh thereof to be so delycate

to his tongue, set to amayne without al fear. The which theyse companions perceiving, were not behynde hym in greedynesse; insomuche that they had now none other talke than of the sweetnesse of these serpentes, which they affirm to be of more pleasantt taste than eyther our phesantes or partriches."

The eggs of the larger lizards are also used as food in some countries.

Though snakes are esteemed as food in many lands, it is not likely that they will ever be an important article of diet in this country, both because of the almost universal repugnance with which they are regarded and because of the comparative scarcity of large serpents within our borders. Our larger black snakes, though reaching a considerable length, are so slender that the amount of flesh in their bodies is not great, and there is probably hardly one person in ten thousand who would knowingly eat a snake.

With the crocodilia the matter of size cannot be raised as an objection, since the largest members of this order may reach a length of thirty feet and a weight of many hundreds of pounds. Of course, neither an alligator nor a crocodile is a very attractive looking animal, but when skinned and dismembered the body looks no more repulsive than any other carcass that may be seen in any butcher's shop, and the flesh is as white and attractive-looking as the best beef or pork. The eggs of the crocodilia, which are usually about as large as those of a goose, are often eaten by the natives of the tropics. Never having eaten an alligator *egg*, I can not speak from personal experience of its flavor; but it has always seemed strange to me that more use is not made of the flesh of the alligator. This flesh is often said to have too strong a flavor to be palatable; I have eaten it, and it had no such rank taste, but was decidedly agreeable, being, as might perhaps be expected of so amphibious an animal, somewhat like both fish and flesh, yet not exactly like either. Perhaps greater care should be taken in skinning an animal that is to be used for food in order that the flesh be not tainted with the musk. It may be a lack of care in preparation that has given rise to the impression that alligator meat is too strong to be pleasant. It is perhaps, also, the "idea" of eating a reptile that makes the meat unpopular. A half-grown boy, who was once in the swamps with me, had expressed a great aversion to alligator meat, so the guide, one day, offered him a nicely fried piece of alligator meat, saying it was fish; the meat was eaten with evident relish and the diner was not told until after a second piece had disappeared what he had been eating.

It always seemed strange to me that the poor people of the south should not more often vary the monotony of fat pork and corn bread with alligator steaks. Whether the meat could be smoked, or salted or canned so that it would keep in a hot climate I do not know; I am not aware of any experiments along this line. But it would seem as though it could at least be canned as well as any other kind of meat.

Another point that would have to be determined is whether the flesh of the crocodilia of Central and South America is as pleasant to eat as that of the Florida alligator noted above, because the latter animal has been so persistently hunted by sportsmen and hide hunters that its members have been greatly reduced, in fact, almost to the verge of extinction in many regions. In many parts of tropical America the various species of crocodiles and caymans are said to be very abundant, so that if a means could be devised to preserve the flesh near the place where the animals are killed, a large supply of meat might be obtained. At the same time, the hides, though not of such good quality as the Florida skins, might be of considerable value in these times of scarce leather.

It is probable that, on account of the general prejudice against eating reptiles, it would be necessary to give the commercial product some trade name, such as is being used to induce the finicky American public to eat certain sharks and other perfectly good sea fishes. The selection of such a name would be an easy matter, and if the canned "Yacare," as the flesh of the cayman is called in South America, should prove as palatable as the freshly fried alligator steak, it would have a ready sale.

We Americans have a lot of silly ideas about what is fit for food and what is not, and it is time that we got rid of some of them.

ENTOMOLOGICAL RESEARCH AND UTILITY

By DR. E. P. FELT

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THERE has been no period when there was more demand for practical means for the control of insects—methods which could be applied in the garden, the field and even forests and yield results commensurate with the costs. The reason is found in the high prices of all crops and the urgent need of greater production. The latter may be secured by increased planting or better protection and usually by a combination of the two, since a greater acreage is easily offset by insect depredations or other untoward developments. It is only necessary to recall that estimates made several years ago of the total annual losses caused by insects in the United States overran the billion-dollar mark and to-day probably approach twice that sum. This gives an idea of what insect activities mean in a practical way. A large proportion of this waste is preventable and if it were eliminated would go far to relieve the burden of taxation.

All manner of crops, animals and products are levied upon by insects. Wheat may be blasted by the Hessian fly, green aphid and wheat midge; potatoes seriously damaged by potato beetles, wire worms and white grubs; corn destroyed by white grubs, corn root worms or army worms; cotton has its enemies in the cotton boll weevil and the cotton worm; stored food products may become infested by meal worms, contaminated by roaches and spoiled by weevils; fabrics are ruined by clothes moths; lumber and even dwellings are rendered worthless by various borers, while our domestic animals are worried by horn flies and driven to desperation by black flies and gadflies. Man is by no means exempt from attack by malevolent forms such as body lice, especially in the trenches; the house fly with its disease-carrying potentiality is a menace in both home and camp, and the same is true of a number of mosquitoes. This has all become increasingly important under present conditions, especially in the field and camp, where opportunities for protection are greatly reduced and the chances for infestation increased on account of the frequent changes and enforced associations.

In other words, the menace of the insect has become immensely greater and with changing conditions incident to war, especially in those unfortunate sections blighted by military activities, there will be new adaptations on the part of the more

destructive insects. The lower type of agriculture due to the lack of labor and the absence of sufficient fertilizers is apt to be followed by insect injury of a type now largely restricted to less progressive regions. The grasshopper, that plague of ancients and devastator of the western plains, especially in earlier days, may find among the scanty crops of poorly cultivated fields conditions favorable to extended depredations. This period of readjustment is the time when most careful attention should be given to insect life and the causes favoring its development. There is a special need for searching out ways of preventing loss by modifications in practise, since many of the remedial operations such as spraying may be made impossible owing to a lack of labor and an absence of means. There is no extra expense, for example, in delaying the sowing of wheat until danger of attack by the Hessian fly has passed. It costs practically nothing to modify crop rotations so that corn and potatoes will not be planted on sod land badly infested by white grubs or wire worms, thus inviting disaster. Such matters are of great importance in times of stress. We should know that the successful prevention of injury in any such manner must depend upon an exact knowledge of habits and limitations, something which can be acquired only by years of experience or through painstaking investigations.

Introduced and new insect pests also present serious and in some cases acute problems which may demand immediate solution if extended depredations are to be avoided. It is well known, for example, that over half of our most injurious insects have been introduced from abroad, and during recent years there have been formidable additions to the number, such as the gypsy moth, the brown tail moth, the pear thrips and the cotton-boll weevil, to mention only a few. This process is continuing and no one can foresee its limits. The past season has witnessed the discovery in New York state of an apple and thorn skeletonizer, a European insect capable of defoliating entire orchards and one which appears to have become recently established in this country. Native species are responding to changed environment and causing losses which can not be prevented without the direction possible through exact knowledge of the life history and habits of the pest. Both the introduced species and native insects which become seriously injurious give little warning of their destructive abilities and frequently arise from the ranks of the previously unknown or almost ignored. This class of pests alone justifies long continued studies in unraveling the numerous biological problems presented by insect life, since no one could foretell what facts, though apparently insignificant of themselves, may determine

the possibility of practical control for widespread and destructive pests.

The assembling on fields of battle of representatives from all parts of the world, and the inevitable later scattering of units means the establishment in many localities of individuals infected with most of the diseases to which man is heir, and with a presumptive relaxation of the present rigid military control upon the establishment of peace, there will be an unexampled opportunity for various insects to serve as carriers of deadly infections so frequently associated with war, such as typhus, bubonic plague, cholera, typhoid fever, dysentery and smallpox, most of which may be carried by insects even if they are not largely disseminated in this manner. Only the most thorough precautions can prevent extensive outbreaks of these diseases, and certain safeguards are possible only when there is an intimate knowledge of the habits of the insects serving as carriers. The warstricken areas lack the ordinary sanitary provisions, and the numerous cases of noxious diseases occurring therein can not but serve as centers for the dissemination of infection among an unusually susceptible population due to the lowered vitality incident to exposure and deficient nutrition. This is the situation obtaining in some sections of the world and very likely to spread over considerable areas unless the danger is fully appreciated and every possible precaution adopted.

Practical insect control depends absolutely, whether it be recognized or not, upon exact knowledge of the life history and habits of insects. Outbreaks by various pests are simply responses to environments and it is the duty of the scientist to read carefully the pages of history and determine so far as practical what portions are to be repeated in the near future. Changes in agricultural methods are inevitable with the scarcity of help, and we must see to it that such modifications do not produce unduly favorable conditions for insect outbreaks. We must anticipate unexpected mischief so far as practical, and this for the entomologist is no small undertaking when the enormous number of species he is called upon to deal with is taken into account. This is no time to restrict research. There should rather be a great extension of activities if the entomologist is to render the best service to his country and to mankind. He should seek as never before for the limiting factors which render an insect innocuous and if possible prevent it becoming unduly abundant and destructive. This should be a campaign of knowledge directed largely toward preventive measures, since combative and remedial measures may frequently be impossible.

POTHOLES: THEIR VARIETY, ORIGIN AND SIGNIFICANCE¹

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INTRODUCTORY—OCCURRENCE AND TERMS USED

WHERE streams have eroded channels in bed rock, hollows of characteristic shape, called "potholes," commonly appear. In ground plan potholes are typically circular or elliptical, but often deviate from this ideal shape. As a general rule such depressions are of less diameter at the top than in their middle sections or bottoms.

The term "pothole" has at various times been criticized by geologists, notably by Hershey² on the ground that the word "is inelegant and grates harshly on people of sensitive temperament." He suggested the use of the term "remolino," a Spanish word used in the Republic of Colombia for such hollows. Hershey's proposal elicited several comments for and against the use of this term. Farrington³ favored the substitution, because, according to his idea, "remolino" suggested more adequately than "pothole" the manner of formation of the holes. Hilder,⁴ on the other hand, pointed out that the Spanish word has several meanings, for example, "a whirlpool" or "whirlwind," and that it had even been applied to a turbulent mob of people.

In geological literature there are many articles describing "giants' kettles." These papers refer almost exclusively to that type of pothole development due to the work of glacial waters. There seems to be a paucity of articles dealing with

¹ To Prof. O. D. von Engeln, at whose suggestion this investigation was begun, the writer is indebted for friendly advice and interest shown during the progress of the investigation.

The writer greatly appreciates the kindness of Mr. G. H. Hudson of Plattsburg, N. Y., and Mr. G. F. Morgan, of Ithaca, N. Y., in supplying and permitting the use of several of their photographs.

² Hershey, O. H., "Pothole vs. Remolino," *Science*, N. S., Vol. X., p. 58, 1899.

³ Farrington, O. C., "Pothole vs. Remolino," *Science*, N. S., Vol. X., p. 187, 1899.

⁴ Hilder, F. F., "Pothole vs. Remolino," *Science*, N. S., Vol. X., p. 88, 1899.

potholes that have been sculptured by existing streams or that are now in process of development along such stream courses.

The primary purpose of this paper is, therefore, to describe and account for the existence of pothole hollows in the channels of existing stream courses, giving especial attention to observation of such phenomena as they occur in horizontally bedded strata composed of shales and sandstones.

Since, however, potholes have always excited considerable popular interest and as such phenomena are by no means all of the normal type to which the principal discussion refers, a review of some of the earlier literature on the origin of such depressions, together with an attempt to classify and briefly describe the several variant types, will serve to give the reader an appreciation of the broader aspects of the subject.

EARLY IDEAS CONCERNING POTHOLES

In the earlier literature, generally with reference to occurrences in glaciated regions, the terms, "giants' kettles," "giants' caldrons," "Indian kettles," "Indian mortars" and "wells," were often applied to potholes; indicating that their origin was either superstitiously ascribed to the work of giants, primarily because of their large size, or referred to the handicraft of the North American aborigines. Brögger and Reusch⁵ cite several examples from Norway of fanciful notions regarding the origin of such hollows. In one instance where a large pothole excavation had been cut through by a road, the belief is that "there St. Olaf turned his horse round" and in other instances from the same region the idea prevailed, that, since occasionally the holes resemble in outline the print of a human foot, they are footprints left by giants while taking huge strides across the country. On the west coast of Norway the term "*gygre-serrer*," or "giants' chairs" is used in referring to potholes. Again, according to Brögger and Reusch,⁶ one of the early writers, Neels Herzberg, had both strange and rational ideas concerning the hollows. He suggested that they were due to the power of lightning, or to the activities of a monster sea worm, of which he thought examples were perhaps still to be found in the deep, such animals having "worked them out in olden times, before the rock had hardened, just as boring mussels do in our day in a small way." Herzberg thought it

⁵ Brögger, W. C., and Reusch, H. H., "Giants' Kettles at Christiania," *Quart. Jour. Geol. Soc. of London*, Vol. 30, p. 750, 1874.

⁶ Brögger, W. C., and Reusch, H. H., "Giants' Kettles at Christiania," *Quart. Jour. Geol. Soc. of London*, Vol. 30, p. 762, 1874.

not impossible that potholes might be formed by ordinary rain-drops during the lapse of a tremendous period of time, in the same manner that he had seen a miniature kettle hollowed out by twenty-two years' continual dropping of water on a flagstone outside his window. Although Herzberg entertained such varied ideas of pothole origin he also seems to have hit upon the true explanation of the normal type for he says, "they seem to be formed by the breaking of the waves, the whirl of the water and currents, which have ground stones and rubbish round inside them."

In North America the idea seems to have prevailed at early dates that the potholes were the work of the aborigines, as is indicated by a quotation cited by Manning:⁷

General Joseph Sewall in his "History of Bath, Me.," says: "Neither history nor tradition informs us how they [the potholes at Bath, Me.] were made, or for what purpose. By some they are supposed to have been used in the performance of some of the religious ceremonies of the nation. An examination of them seems to leave but little doubt that they were made and used by the natives to boil their food in; so limited was their knowledge of the arts and so rude their implements, that they heated water for cooking by throwing stones into it; the pebbles found in and about these holes are such as would resist the action of heat, and, as if by much use, they are all worn and smooth; and the sides of the holes toward the sea being a little lower than the others, by their smoothness show the effect of the action of the pebbles as they were rolled in and taken out of the excavations."

Similar ideas obtain even now in the western states. Turner⁸ describes a large group of glacial potholes in granite in the canyon of the North Fork of Mokelumne river, California, about 30 miles southwest of Lake Tahoe. The locality is known as Harris' Salt Springs. The holes, about 250 in number, are from 6 inches to 6 feet apart. The interiors of all the holes are well-rounded and smooth. They extend over an area of about 2,000 square feet. In this locality salt water oozes from crevices in the rocks and collects in several of the lower holes, the water usually being covered with sodium chloride crystals. Indians are said to have congregated here, attracted no doubt by the salt springs. Many small arrowheads are found near by as are also several small mortar holes such as are used by Indians to grind up acorns. The guides and old settlers acquainted with the vicinity accordingly argue that the holes were made by Indians for the purpose of collecting the salt

⁷ Manning, P. C., "Glacial Potholes in Maine," *Portland Soc. Nat. Hist. Proc.*, Vol. 2, Part 5, p. 190, 1901.

⁸ Turner, H. W., "Glacial Potholes in California," *Am. Jour. of Sci.*, 3d Series, Vol. 44, pp. 453, 454, 1892.

water in order to bring about the concentration of the salt crystals. While the old settlers did not know personally of any such holes being excavated by Indians, it seemed to them that it would not be difficult for Indians to make the holes by building fires on the granite, allowing the rock to cool and repeating the process a number of times, eventually causing the rock to shell off, meanwhile using such tools as they possessed to facilitate the development of the holes.

In view of these early popular misconceptions of their origin, and since similar ideas are still current in some sections; and further because all types of pothole depressions are not to be explained by any one process, it has seemed worth while to attempt a rational classification of these phenomena on the basis of their mode of formation and then to describe briefly each of the types.

CLASSIFICATION OF POTHOLE DEPRESSIONS

Class A—Allied types of pothole excavations due to the erosive action of water aided by rock fragments and sediment tools, in the general order of their size from largest to smallest.

1. Moulin potholes or giants' kettles.
2. Plunge pools.
3. Normal potholes.
4. Cupholes and Joint wells.

Class B—Types of pothole-like excavations due primarily to solution.

1. Solution potholes.
2. Dent pits.

Class C—Types of pothole-like excavations of rather uncommon occurrence, due to solution, erosion and other processes acting in combination or singly.

1. Tide pools.
2. Potholes due to sea urchins.

Class A, Type 1:

Moulin potholes (also called glacial potholes) are in general to be correlated with what are popularly termed giants' kettles and are associated in origin with the melting of glacial ice. They have perhaps attracted more attention than any of the other types because of their frequent occurrence away from present stream courses. In some cases no other marks of water action are to be noticed in their vicinity. It is particularly interesting to note that in potholes of this type, according to Upham,⁹ "generally the edge or lip of the giants' kettles (moulin potholes), whether large or small, is abruptly cut in the rock

⁹ Upham, W., "Giants' Kettles Eroded by Moulin Torrents," *Bull. Geol. Soc. of Am.*, Vol. 12, pp. 40-41, 1900.

surface, perhaps sometimes because of their partial removal at the surface by glaciation subsequent to the moulin erosion." "They seldom have a flaringly curved mouth, such as more frequently characterizes potholes seen at the present time in the process of erosion by cascades in brooks and rivers."

Moulin potholes are commonly very large. Upham¹⁰ describes several in the Interstate Park of the Saint Croix Dalles, Wisconsin, among which is one with a diameter of 27 feet, and another that has a diameter of 15 feet and which has a depth of at least 65 feet. A third occurrence in the same locality has a diameter of 12 feet. The depth of this hole according to Upham¹¹ is stated by Dr. C. P. Berkey to be 160 feet. The moulin potholes of the "Glacier Gardens of Lucerne" in Switzerland are perhaps the best known. Barker¹² has described two potholes of this type located at Crown Point, New York. It should be noted that glacial potholes are of wide distribution; are apparently coextensive with regions of continental glaciation and are also found adjacent to existing glaciers of the Alpine type. Gilbert¹³ ascribes these potholes to the work of a moulin or glacial mill which is a stream of water plunging from the top to the base of a glacier through a well of its own maintenance. The water, which is chiefly derived from ice melting, usually has a short course as a stream on the surface of a glacier before reaching the well, and it escapes from the bottom of the well by a channel under the glacier. The moulin originally forms in a crack or crevasse, and in its initial stage the crevasse must extend from the top to the bottom of the ice mass to admit and transmit the water stream. After a time the crevasse generally becomes sealed by regelation except where the falling water maintains an opening. Thus a vertical fall develops and the stream strikes the rock bed beneath with great force. Boulders and sand are carried by the surface stream to the well and at the base of the ice the plunging water picks up rock fragments and sand from the ground moraine and this material is used as tools with which to attack the rock bed. With long enough continuance of such action a hole is formed which deepens and assumes the character of a normal pothole of very large size.

¹⁰ Upham, W., *Ibid.*, pp. 30, 31.

¹¹ Upham, W., "Giants' Kettles Eroded by Moulin Torrents," *Bull. Geol. Soc. of Am.*, Vol. 12, p. 31, 1900.

¹² Barker, E. E., "Glacial Potholes at Crown Point, N. Y.," *Jour. Geol.*, Vol. XXI., No. 5, July-Aug., 1913, pp. 459-464.

¹³ Gilbert, G. K., "Moulin Work under Glaciers," *Bull. Geol. Soc. of Am.*, Vol. 17, pp. 317-320, 1906.

Because it is self evident that a moulin can not maintain itself for an indefinite period in actively moving ice it seems incredible that such large holes in the bed rock could be ground out in the time available. But it is to be noted that moulins develop primarily at the lower ends of very stagnant and inactive glaciers and, further, that the fall of the water may be of very great height. Thus Lubbock¹⁴ relates that the depth of a moulin on the Finster-Aar glacier was found to be 232 meters. This depth would undoubtedly lead to great force in the fall of the water. The mere impact of the water, however, has very little to do with starting the holes, according to Stone.¹⁵ It is chiefly the stones and sediment rolled about that erode. The falling water develops tremendous swirls at the base and these keep the rock tools in active motion. The moulin potholes of regions of continental glaciation are however thought by Upham¹⁶ to have been formed during an early stage of the glaciation, since during that stage the supply of tools would not be too great, as he says would be the case during the latter part of the glacial period.

Class A, Type 2:

Plunge pools are potholes, in general, of large size, occurring at the foot of a vertical or nearly vertical waterfall. At such sites the velocity of the falling water develops especially great energy in swirling stones at the foot of the plunge, and this results in the grinding out of potholes or plunge pools of exceptional diameter (depending on the volume of the water) and depth (depending apparently on the height of the fall). A large plunge pool occurs at the base of the Canadian side of Niagara Falls. According to Spencer,¹⁷ the depth of this pool is 72 feet. In most plunge pools the water is much deeper than it is in the stream channel on their downstream side. Smaller waterfalls develop plunge pools that quite closely resemble normal potholes. In fact there are practically all gradations from plunge pools to the normal type of pothole formed in existing stream channels. It must not be inferred from this, however, that all potholes in existing stream channels are initiated

¹⁴ Lubbock, Sir John, "The Scenery of Switzerland," Macmillan Co., 1898, pp. 92-93, 122.

¹⁵ Stone, G. H., "The Glacial Gravels of Maine and their Associated Deposits," U. S. G. S. Monograph, 34, pp. 324-326, 1899.

¹⁶ Upham, W., "Giants' Kettles Eroded by Moulin Torrents," *Bull. Geol. Soc. of Am.*, Vol. 12, pp. 25-44, 1900.

¹⁷ Spencer, Dr. J. W. W., "Soundings in Niagara Gorge and under the Falls," *Sci. American*, Vol. 99, Aug. 1, 1908, pp. 76-77.

by waterfalls however small. This fact is illustrated in Fig. 2 which shows quite clearly that a pothole may become a plunge pool.

Class A, Type 3:

Normal Potholes.—These potholes occur in the beds of present day streams or recently abandoned stream courses, in places over which the water has flowed either constantly or during its periods of high volume. If still in the process of formation they must be located directly in the course of the water channel at least during occasional periods of flooding. One of the distinguishing characteristics of normal potholes is the presence of waterworn surfaces adjoining the hole. Normal potholes are described in greater detail below.

Class A, Type 4:

Cupholes have been described by Hudson¹⁸ as little potholes that have been cut, not by pebbles, but by sand and silt swirled about by water currents. They rarely exceed 12 centimeters in diameter and may be cut on very steep slopes of a rock surface. According to Hudson,¹⁹ cupholes are somewhat V-shaped, more strictly speaking,—parabolic in vertical sections. (See Figs. 3, 4, and 5.)

The same author also describes *joint wells*²⁰—another type of small depressions that occur along joints in rocks that have suffered glaciation. It is his opinion that *joint wells* (see Fig. 6) were cut by combined solution and silt erosion processes and that they are embryonic moulin-potholes in that they are the work of subglacial streams. Hudson, while describing the *cupholes* as “little potholes”²¹ caused by wave and undertow acting on the lake shore, is unwilling to have them classed as a form of *incipient* potholes on the ground that they may never become such. He regards their form as being so different from that of

¹⁸ Hudson, G. H., “Some Items Concerning a New and an Old Coast Line of Lake Champlain,” N. Y. State Mus. Bull., No. 133, 5th Rept. of the Director, 1908, pp. 160–162, 1909.

¹⁹ Hudson, G. H., “Joint Caves of Valcour Island—Their Age and Origin,” N. Y. State Mus. Bull., No. 140, 6th Rept. of the Director, 1909, pp. 170–173.

²⁰ Hudson, G. H., “Rill Channels and Their Cause,” Report of the Vermont State Geologist, 1912, pp. 245–246.

²¹ Hudson, G. H., “Some Items Concerning a New and an Old Coast Line of Lake Champlain,” N. Y. State Mus. Bull., No. 133, 5th Rept. of the Director, 1908, pp. 160–162, 1909.

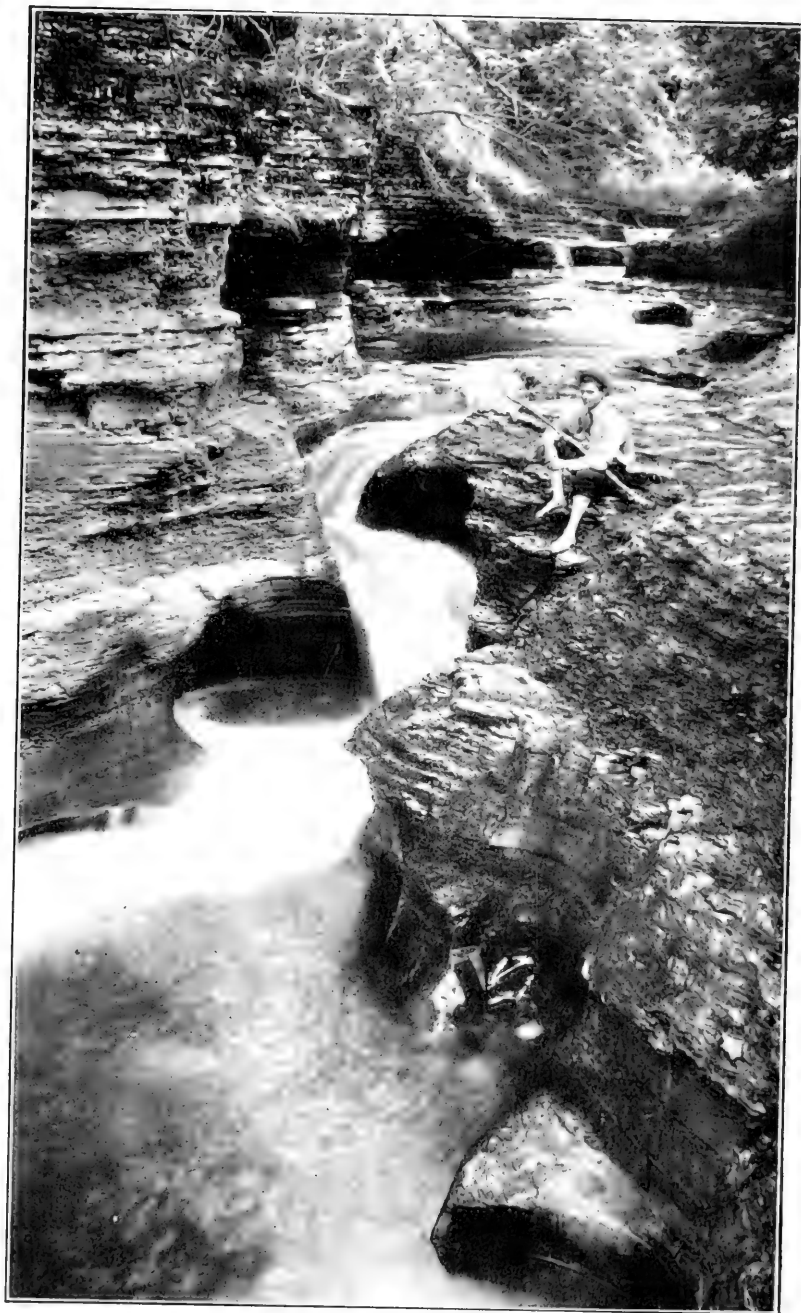


Photo by G. F. Morgan, Ithaca, N. Y.

FIG. 1. INTERSECTING POTHoles IN GORGE OF BUTTERMILK CREEK NEAR ITHACA, N. Y. Such a series of potholes indicates the primary importance of pothole erosion processes in the deepening of stream gorges.



Photo by Libbey.

FIG. 2. SERIES OF PLUNGE POOLS AND A WATERFALL IN LAVA IN HAWAII. Notice how the fully developed pools below the falls have intersected because of enlargement below the water surface thus creating a series of natural bridges. When the pothole at the foot of the falls has developed sufficiently to intersect the base of the similar hollow in the stream bed above, the falls will again retreat and the upper pothole will become a plunge pool. This picture farther illustrates the important part that processes of pothole and plunge pool excavation play in gorge deepening.

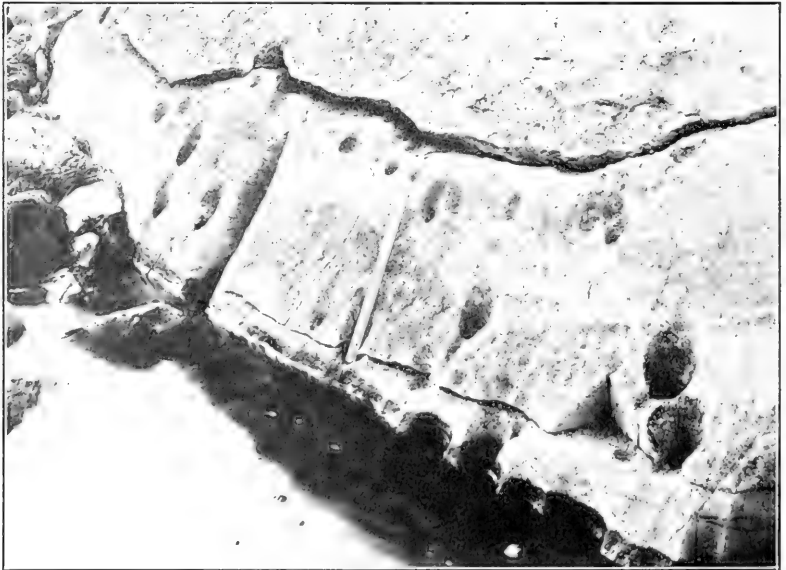


Photo by G. H. Hudson, Plattsburg, N. Y.

FIG. 3. CUPHOLES CUT IN STEEP FACE OF ROCK ON VALCOUR ISLAND.

typical potholes as to entitle them to a name of their own and in a letter to the writer states that they are made by silt and sand carried by vortex motion and that in his opinion the *cupholes* tell of lake conditions or large bodies of water and not of river conditions.

If his interpretation of them is correct, it is possible that the *cupholes* are in origin akin to the so-called tide pools described in another paragraph and hence may be classed as minute forms of normal potholes. Furthermore, it also seems

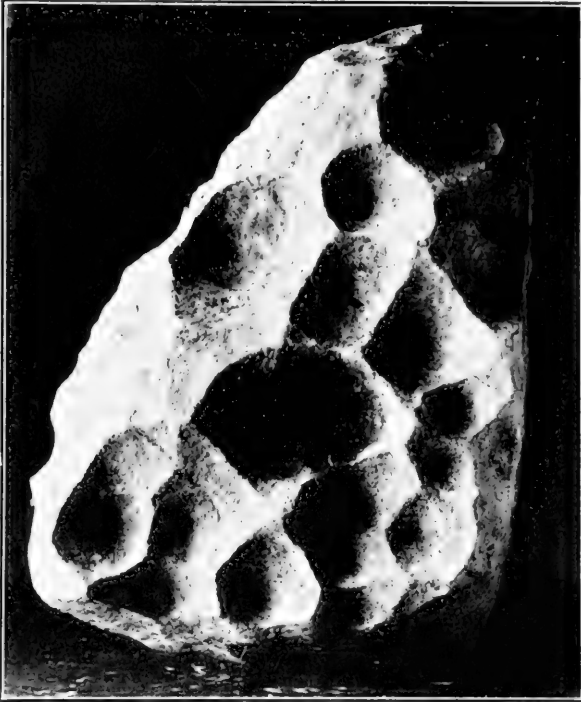


Photo by G. H. Hudson, Plattsburg, N. Y.

FIG. 4. BLOCK OF PURE DOLOMITIC LIMESTONE CUT BY CONFLUENT CUPHOLES. Specimen taken from Valcour Island and is now in the New York State Museum.

probable that the *joint wells* and *dentpits* (a third type of similar small depression) are all very small forms of moulin potholes or solution potholes. Thus the *cupholes* are due primarily to erosive action of fine sediment whirled by the water; the *dentpits* to solution action; while the *joint wells* may be due to both solution and grinding.

Class B, Type 1:

Solution Potholes.—This type includes all the holes that are

formed primarily by solution action. Such holes are most numerous in soluble rocks, notably limestone. They may almost invariably be distinguished from other potholes by the rough solution surfaces of their interiors.

Class B, Type 2:

Dentpits as described by Hudson²² have been previously mentioned as vortex formed, shallow concavities on rather pure calcareous rock where the water carries but little matter in mechanical suspension. They are due mainly to solution and their width greatly exceeds their depth. The diameters of

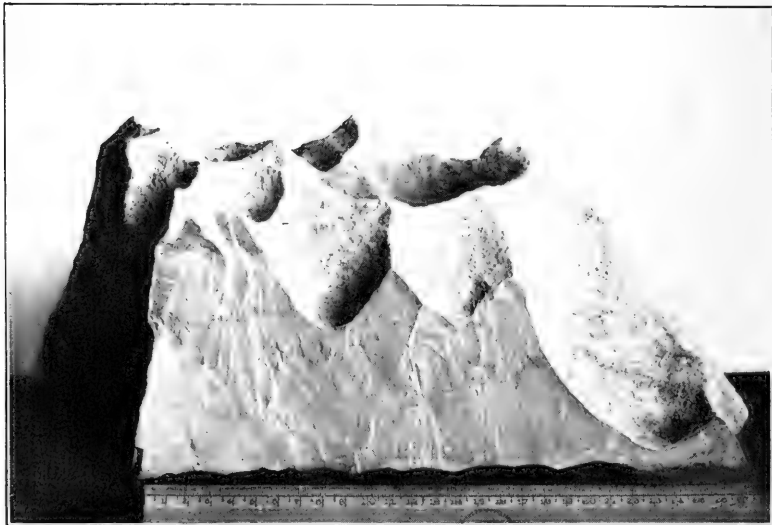


Photo by G. H. Hudson, Plattsburg, N. Y.

FIG. 5. VIEW OF FRACTURED END OF THE LOWER PORTION OF THE BLOCK SHOWN IN FIG. 4. Presents a side view of the cupholes and illustrates parabolic vertical sections of the same. Shows also the edge of the dent-pitted surface below and indicates approximately the quantitative value of the two forms of erosion as geological agents.

dentpits are usually between 1 and 5 centimeters. In vertical sections they present rather circular outlines. No silt is ever found in these depressions which are well shown in Fig. 7.

Class C, Type 1:

Tide pools are a rather uncommon type of pothole depression occurring along rocky coast lines. Their formation seems

²² Hudson, G. H., "Joint Caves of Valcour Island—Their Age and Origin," N. Y. State Mus. Bull., No. 140, 6th Rept. of the Director, 1909, pp. 165-173, 1910.

to be due to a variety of processes. A particular occurrence of such holes along the west coast of Vancouver Island, near Port Renfrew, B. C., is described and explained by Henkel.²³ The principal rock formations at this locality are, in their order from the surface downward, sandstone, conglomerate and shale. In many places the sandstone has been worn away leaving the conglomerate or the shale as the surface rock. Depressions of varying shape and depth are found in all three kinds of rock but are best developed in the sandstone because of the "extreme softness" of this rock. The pools are also numerous in the shale, but only few occur in the conglomerate. In the sandstone the pools generally occur in strata that are nearly horizontal and they are especially numerous in a gently dipping

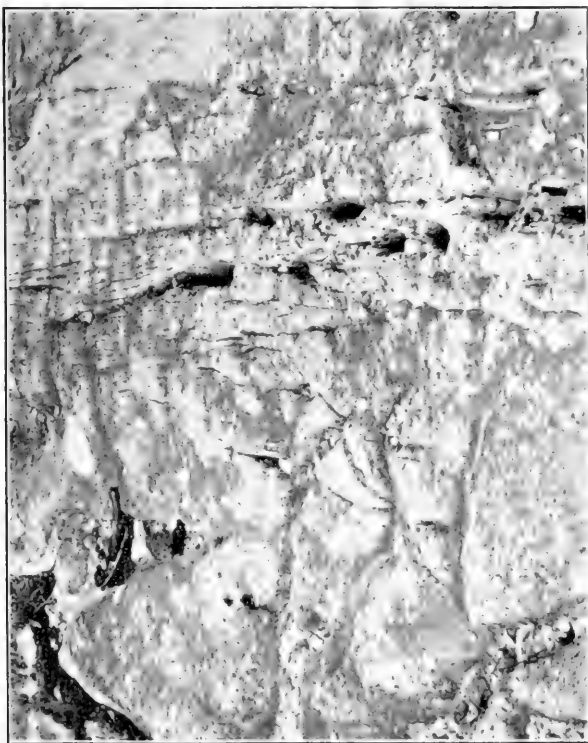


Photo by G. H. Hudson, Plattsburg, N. Y.

FIG. 6. JOINT WELLS IN LIMESTONE LEDGE ON VALCOUR ISLAND.

sandstone which contains many concretions. This formation is locally known as the "devil's billiard table." Apparently

²³ Henkel, Isabel, "A Study of Tide Pools on the West Coast of Vancouver Island," *Postelsia*—The Year Book of the Minnesota Seaside Station, 1906, pp. 277, 304.

the concretions have been worn out in many places leaving a depression. The number, size and irregularity of the pools increases with the slope.

The majority of the smaller pools are circular but the larger ones are generally elliptical and give evidence of having been formed by the union of two or more smaller pools. From depressions a few inches in diameter, the size varies to those 30 feet long, 20 feet wide and 10 to 15 feet deep. Plant and animal life is commonly found in many of the pools, notably sea urchins, mussels and barnacles, and in some pools boulders occur that are apparently of the same composition as the concretions. The larger pools, however, contain the fewer boulders.



Photo by G. H. Hudson, Plattsburg, N. Y.

FIG. 7. THE UNDERSURFACE OF BLOCK SHOWN IN FIGS. 4 AND 5, SHOWING DENT-PITS. Figure should be viewed at an angle that will eliminate the impression of botryoidal surface.

Henkel considers the occurrence of the concretions to be the most potent factor in the development of sandstone pools. After becoming detached from the formation the concretions

are hurled about inside the depressions gradually enlarging them while at the same time the concretions are reduced in size. This process of enlargement may be aided by plant and animal life exerting a disrupting influence upon the rock. Tide pools in general, however, according to this author are initiated by a variety of conditions and processes, among which may be included: cracks in the rock; concretions; lines of stratification; erosion by waves, tides and wind; action of carbon dioxide; variation in temperature, both of water and of the air; and the action of plants and animals.

Class C, Type 2:

Potholes due to sea urchins are depressions occurring along rocky coast lines and are a type very closely resembling Tide Pools. Such potholes are described by Fewkes²⁴ who states that they are comparatively rare. Some were found near Grand Manan, New Brunswick, and also at Biarritz, France. They are apparently most commonly found on coasts beaten by a strong sea and in places where there is considerable tidal variation. It seems that the cavities owe their origin primarily to sea urchins, the teeth and spines of which gradually hollow out the depression. Water action rolling these spiny creatures about, and pebbles also apparently facilitates the development of such pools.

(To be concluded)

²⁴ Fewkes, J. W., "On Excavations made in Rocks by Sea Urchins," *The American Naturalist*, Vol. 24, pp. 1-21, January, 1890.



CHARLES EMILE PICARD

recently elected permanent secretary of the Paris Academy of Sciences in succession to the late Jean Gaston Darboux. Both M. Picard and M. Darboux have been professors of mathematics and have been active in matters of national defense and in increasing the services to the nation of the Paris Academy of Science. Like M. Painlevé the present premier of France, also professor of mathematics, their activities seem to disprove the prevalent idea that mathematicians are not efficient in practical affairs.

THE PROGRESS OF SCIENCE

WORK OF THE CORPS OF ENGINEERS OF THE ARMY

THE Corps of Engineers of the Army since April 6 has not only been supplying the engineer equipment for an army of a million men, but has undertaken the unprecedented task of furnishing railroads complete from the United States for operation in France. The engineers construct the free arteries through which flow great armies, reinforcements, supplies and ammunition to the extremities of the lines.

From March 1 to November 1 the Corps of Engineers increased its personnel from 256 officers on the active list to 394 officers and 14 retired officers on active duty and in addition has commissioned more than 5,000 reserve officers. The enlisted force has expanded from 2,100 to 95,000, and there has also been a heavy increase in civilian employees. In addition, nine railroad regiments and one forestry regiment have been raised as part of the National Army, Seventeen pioneer regiments have been authorized as part of the National Army and are rapidly organizing. National Guard units, equivalent to about seven regiments, have been called into the Federal service, and their reorganization into 17 pioneer engineer regiments for the 17 divisions of National Guard troops is well under way.

Engineer officers' training camps were established in each of the 16 training camp areas the number of candidates for engineer commissions taken from each camp being 150. After a month's training in the same camps with candidates for commissions in other branches of the service the engineer sections were transferred to three engineer training camps with special facilities for

technical instruction, one in the vicinity of Washington, one at Fort Leavenworth, Kans., and one at Vancouver Barracks, Wash. Instruction was continued there for two months. In August, 1,900 candidates were graduated and are now holding commissions.

Large numbers of engineer graduates of training camps have been assigned to new regiments and special units are being organized and the training of enlisted men in the National Army will be largely under their supervision. A number are in France for special training. On December 1 about 1,200 Engineer Reserve officers will be graduated from a second engineer officers' training camp.

A duty imposed upon the engineers has been the purchase of the necessary engineer equipment for more than 1,000,000 men. The urgent deficiencies act approved June 15, 1917, appropriated for the purpose amounts aggregating in excess of \$130,000,000, an amount comparable with the purchase of material equipment, and supplies for the Panama Canal during the ten years of its construction. The urgent deficiencies act approved October 6, 1917, provides \$198,100,000 additional for engineer purposes and it is expected that all of this will be expended during the present fiscal year.

Within 350 hours after the Engineer Corps, following the declaration of war, advertised for equipment, awards had been made covering the requirements of 1,000,000 men, a total of 8,700,000 articles, which included among other items 4 miles of pontoon bridge. Approximately two months was the average time of delivery secured on all

of this material. On September 7, two weeks after receipt of instructions, equipment was en route to the various National Guard and National Army organizations at cantonments throughout the country. These shipments comprised a total of about 48,000,000 pounds in some 64,000 separate cases and packages.

By November 1 the outstanding obligations on orders placed for engineer material, equipment, and supplies, aggregated \$130,000,000, and disbursements in payments for material delivered had reached the sum of \$15,000,000 per month. Another important task of the engineers has been to provide efficient methods for the receipt, storage, and shipment abroad, with proper accounting system, for this mass of supplies as well as for the vast equipment for field operations and construction work.

The engineers of the railway section have undertaken to transport and install and put into operation overseas a complete railroad equipment. The railway problem in the theater of operations in France involves not only the organization, equipment and military training of railroad troops for the construction, maintenance and operation of standard and narrow gauge roads necessary for the supply of our armies, but also the purchase, inspection and shipment of immense quantities of railroad equipment—rails, ties, locomotives, cars, shop tools, etc.—necessary for the development of adequate port facilities, construction of new lines and their successful operation. The estimate of the situation in France was confirmed by the French commission, headed by Marshal Joffre, and the means of meeting it have been carried on with intensity.

Trained officials in various departments of American railroads were called upon for the officers, and ex-

perienced railroad employees for the enlisted men, of the nine railroad regiments, each of 33 officers and approximately 1,100 men.

The cost of materials ordered to date is approximately \$70,000,000 including some hundreds of locomotives, more than 100,000 tons of steel rails, more than 3,000 complete turnouts, 500,000 ties, 12,000 freight cars, 600 fill and ballast cars, 600 miles of telephone wire and apparatus, as well as vast quantities of construction and repair equipment.

The engineers have also undertaken the work of organizing and equipping special troops for special services, such as lumber supply, road construction, sanitary construction, camouflage service, gas and flame service, mining work, mapping, etc. Preferred attention has been given to the organization and equipment of the first forestry regiment, to be sent to France to produce lumber and timber from French forests. Three additional regiments are to be organized. The cooperation of the Forestry Service of the Department of Agriculture has been extended in the selection of personnel and equipment. In addition to all of these duties, the Engineer Corps has maintained its regular service in the preservation and improvement of navigable waters in the United States and construction of coast defenses. New batteries are being pushed to completion with energy.

THE NATIONAL ASSOCIATION OF AUDUBON SOCIETIES.

THE European war has so stimulated a study of the economic uses of birds that the National Association of Audubon Societies was able to report at its annual meeting on October 30 that its sustaining membership had increased thirty-three and a third per cent. during the last year. The growth of the society and the generous financial support

which it has received encouraged its secretary, Mr. T. Gilbert Pearson, to suggest a campaign for the raising of funds with which to build a permanent headquarters for the association in New York City.

The National Association of Audubon Societies, with which are affiliated 134 organizations throughout the U. S., has been devoting special attention to the protection of birds which help conserve crops by destroying weed seeds, rodent pests and injurious insects. This, in no small measure, is regarded as the reason for the movement being joined by so many prominent and influential persons who have been impressed by this service in behalf of the American people. During the year the association enrolled one patron and one hundred and eleven life members. The sustaining membership increased from 3,024 to 4,030.

A significant indication of the activity of the association in conservation the last year is given by the reports of the wardens. In the twelve months just closed forty-six wardens were employed and patrol boats were provided for three additional government wardens. During the year the association put in commission a new warden patrol boat on Klamath Lake, Oregon, while another such craft to be paid for by the income of the Mary Dutcher Memorial Fund is being built for work on the Pelican Island Reservation, Florida. An important feature of the work is the guarding of colonies of aquatic fowl. Reports of the wardens of rookeries show that in the aggregate something over 1,043,000 water-birds were bred in the various protected sanctuaries. This estimate covers forty species including gulls, skimmers, terns, egrets, herons, ibises, pelicans, and a few quillemons, eider ducks, Florida ducks, limpkins, and puffins. Innumerable small birds and various

migratory shore-birds also found protection in these guarded areas.

Coordination of the work of the national association and the state and local endeavors is bringing splendid results in bird protection. Some places recently set aside for the welcoming of the feathered hosts are the Julia Hanson Bird Reservation at Fort Meyers, in Florida, while the entire community at Winter Park in that State has been made an avine haven. Indiana reports that a sanctuary has been established near Muncie and also that a new State Park has been created and designated McCormick's Creek Canyon Bird Reservation. The Beaver Field and Audubon Club has recently established a twenty-five acre sanctuary at Beaver, Pennsylvania.

An important new development of the work of the association is the Saturday morning bird-walk which starts at eight o'clock from the Music Stand at the head of the Mall, Central Park, New York City, weather permitting. The leader of this weekly expedition in birdland is Mr. Walt F. McMahon, of the headquarters' staff. The object of the Saturday walks is to demonstrate to the teeming millions of the metropolis that in the very center of a realm of towering buildings there is a wild life as interesting as that of the distant thickets and forests. The lecturer in his addresses in which he reviews the observations of an hour is able to impress many lessons concerning the economic uses of birds. This work will undoubtedly extend to other cities.

The association has formed in the last year in the United States and Canada 11,935 Junior Audubon Clubs, with a total membership of 261,654 paid members, among the school children of the nation, an increase of 50,000 over 1916. This work, as heretofore, was financed to the extent of \$5,000 by Mrs. Russell

Sage and by \$20,000 from a benefactor of the birds whose identity as far as is known has never been discovered by anyone, save the gentleman who annually sends the checks. After five years during which \$94,000 have been received from this source, the only knowledge that the secretary has regarding the donor is that the money probably comes from a man. The educational work of the National Association has been extended in many other directions through field agents, lecturers, summer schools, exhibitions and by the distribution of large quantities of literature. In every branch there has been manifested a growing interest in this important enterprise which has done so much for the protection of the birds and animals of field and forest.

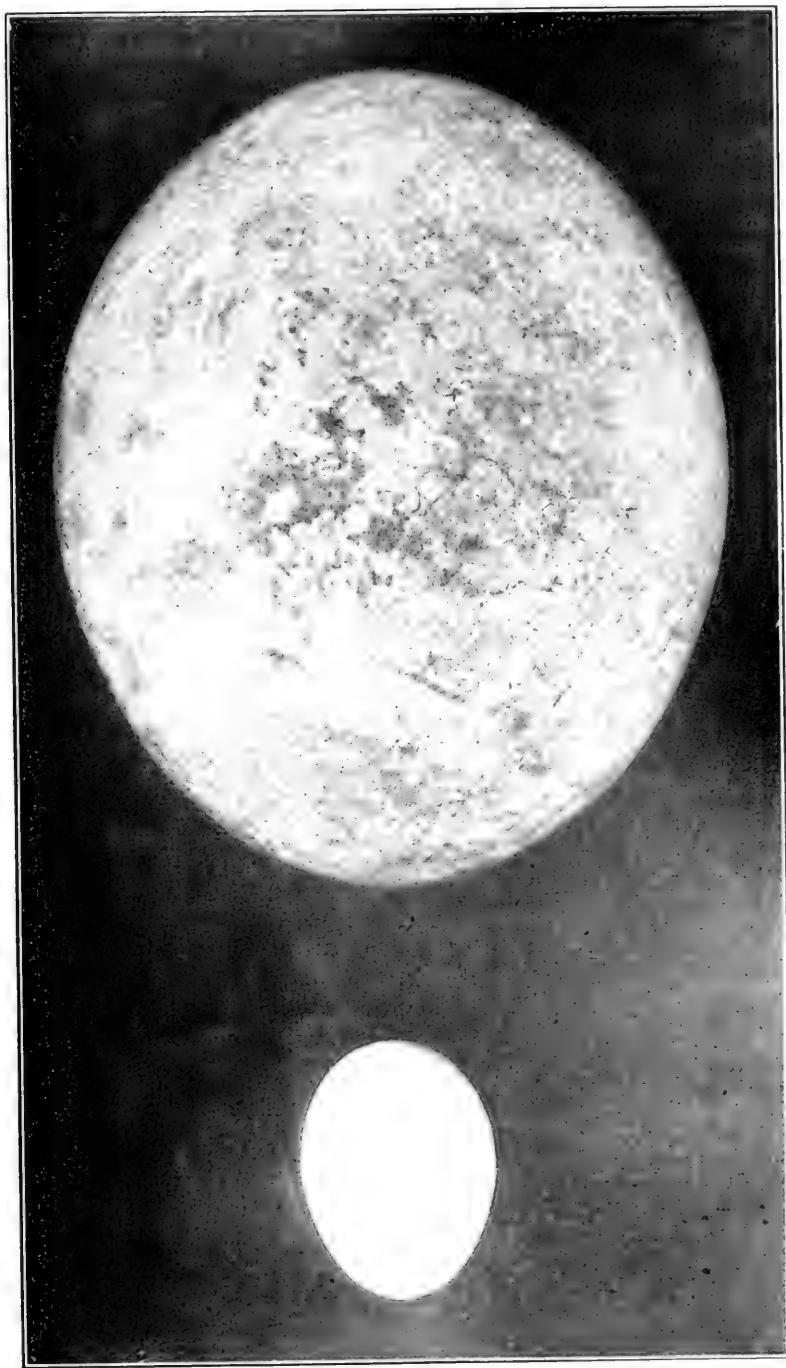
THE CAUSES OF DEATH BY OCCUPATION

BASED upon 94,269 deaths of male and 102,467 deaths of female industrial policyholders, 15 years of age and over, as recorded in 1911, 1912 and 1913, by the Metropolitan Life Insurance Company, tuberculosis caused the death of 20.5 per cent. of the former and 14.4 per cent. of the latter, while organic diseases of the heart were responsible for 12 per cent. of the deaths of males and 14.8 per cent. of the deaths of females. The average age of men dying from tuberculosis was 37.1 years and of women 34.1 years. Of males the lowest average age at death, 31.1 years, was among those who died from typhoid fever, and of females the lowest average age at death, 29 years, was among those who died at child birth. By occupation, the lowest average age at death was 36.5 years among bookkeepers and office assistants and the highest average age was 58.5 years among farmers and farm laborers. These facts are brought out in tabular form in a bulletin entitled "Causes of death

by occupation," a study made by Louis I. Dublin and recently issued by the Bureau of Labor Statistics of the U. S. Department of Labor.

Tuberculosis was responsible for the largest number of deaths among clerks, bookkeepers and office assistants (35 per cent.); compositors and printers (34.1 per cent.); gas fitters and steam fitters (31.6 per cent.); longshoremen and stevedores (29.2 per cent.); teamsters, drivers and chauffeurs (28.2 per cent.); saloonkeepers and bartenders (26 per cent.); machinists (25 per cent.); cigar makers and tobacco workers (24.1 per cent.); textile mill workers (22 per cent.); iron molders (21.9 per cent.); painters, paperhangers and varnishers (21.9 per cent.); masons and bricklayers (19 per cent.); bakers (18.8 per cent.); laborers (16.4 per cent.); blacksmiths (14 per cent.). Accidental violence was responsible for the largest number of deaths among railway engine-men and trainmen (42.3 per cent.); railway track and yard workers (20.8 per cent.); and coal miners (20.4 per cent.); while the largest number of farmers and farm laborers (16.4 per cent.) died from organic diseases of the heart, due to the facts that the prevalence of these diseases increases with age and that the average age at death of those in this group is higher than any other group.

Similarly, among women the largest number of housewives and housekeepers (15.2 per cent.) died from organic diseases of the heart for the same reasons stated above, while tuberculosis took the largest proportion of clerks, bookkeepers and office assistants (42.4 per cent.); clerks and saleswomen (38.7 per cent.); textile mill workers (35.5 per cent.); dressmakers and garment workers (27.8 per cent.); and domestic servants (15.9 per cent.). The average age at death was 26.1 years among clerks, book-



EGG OF A PREHISTORIC OSTRICH COMPARED WITH A EGG OF THE COMMON HEN

This specimen of the egg of the prehistoric ostrich *Struthio lithus, Chersonensis*, has recently been acquired by the American Museum of Natural History, New York City. It is equal in volume to forty hen's eggs and is twice the size of any egg of the modern ostrich. There are two other fossil eggs of this description in existence, but they are broken; this specimen is perfect. The bones of this species have not been found, so it is known only from the eggs.

keepers and office assistants, and 53.3 years among housewives and housekeepers.

The statistics given in the bulletin indicate that respiratory diseases are prominent where the industrial worker is exposed to colds, drafts and dampness (as among masons and bricklayers) or to violent changes of temperature (as among teamsters, drivers and chauffeurs). Organic diseases of the heart have a high proportional frequency in cases where the work is heavy and the cardiac powers are overtaxed (*e. g.*, among iron molders). Suicide is frequent where depressing influences are present (as among bakers and cigar makers). Typhoid fever is high where questionable water supplies are used (as among enginemen and trainmen, farmers, iron molders and laborers).

SCIENTIFIC ITEMS

WE record with regret the death of Dr. R. H. Ward, known for his work in microscopy and from 1869 to 1892 professor of botany in the Rensselaer Polytechnic Institute; of Sir William James Herschel, discoverer and developer of the system of identification by fingerprints; of William Robert Sykes, the inventor of the lock-and-block system of railway signalling, and of A. J. F. Dastre, director of the laboratory of animal physiology at the Sorbonne, the University of Paris.

A MEMORIAL meeting for Professor Wm. Bullock Clark was held at the Johns Hopkins University on the Sunday afternoon of November 4, President Frank J. Goodnow presided. The speakers were Dr. Charles D. Walcott, the secretary of the Smithsonian Institution; Mr. R. Brent Keyser, the president of the board of trustees of the university; Professors Harry Fielding Reid and J. S. Ames, of the faculty,

and Judge J. T. C. Williams, of the Baltimore Juvenile Court.—A memorial tablet has been unveiled at Oxford, commemorating the life and work of Roger Bacon. The tablet has been fixed to the old wall of the city, dating from early in the thirteenth century, close to the site of the Grey Friars Church in the precincts of which Roger Bacon was buried. The church has long since disappeared, but the position of the burial ground, though not the exact spot of Bacon's grave, is known. After the celebration at Oxford in 1914 of the seven hundredth anniversary of Bacon's birth, it was thought fitting that in addition to the statue then created in the University museum, a permanent and public memorial should be set up as near as possible to the site of the Franciscan friary in which Bacon passed so many years of his strenuous life.

PLANS are well advanced for the Pittsburgh meeting of the American Association for the Advancement of Science from December 28 to January 2. The Carnegie Institute, the Carnegie Institute of Technology and the University of Pittsburgh are uniting in preparing to entertain the association. Dr. W. J. Holland, director of the Carnegie Museum, is chairman of the committee on arrangements, and S. B. Linhart, secretary of the University of Pittsburgh, is secretary of the committee. Secretaries of affiliated societies and of other organizations meeting at this time are requested to send to the secretary as soon as possible the approximate number of members of each organization who expect to attend; and the time for which meetings are to be arranged.

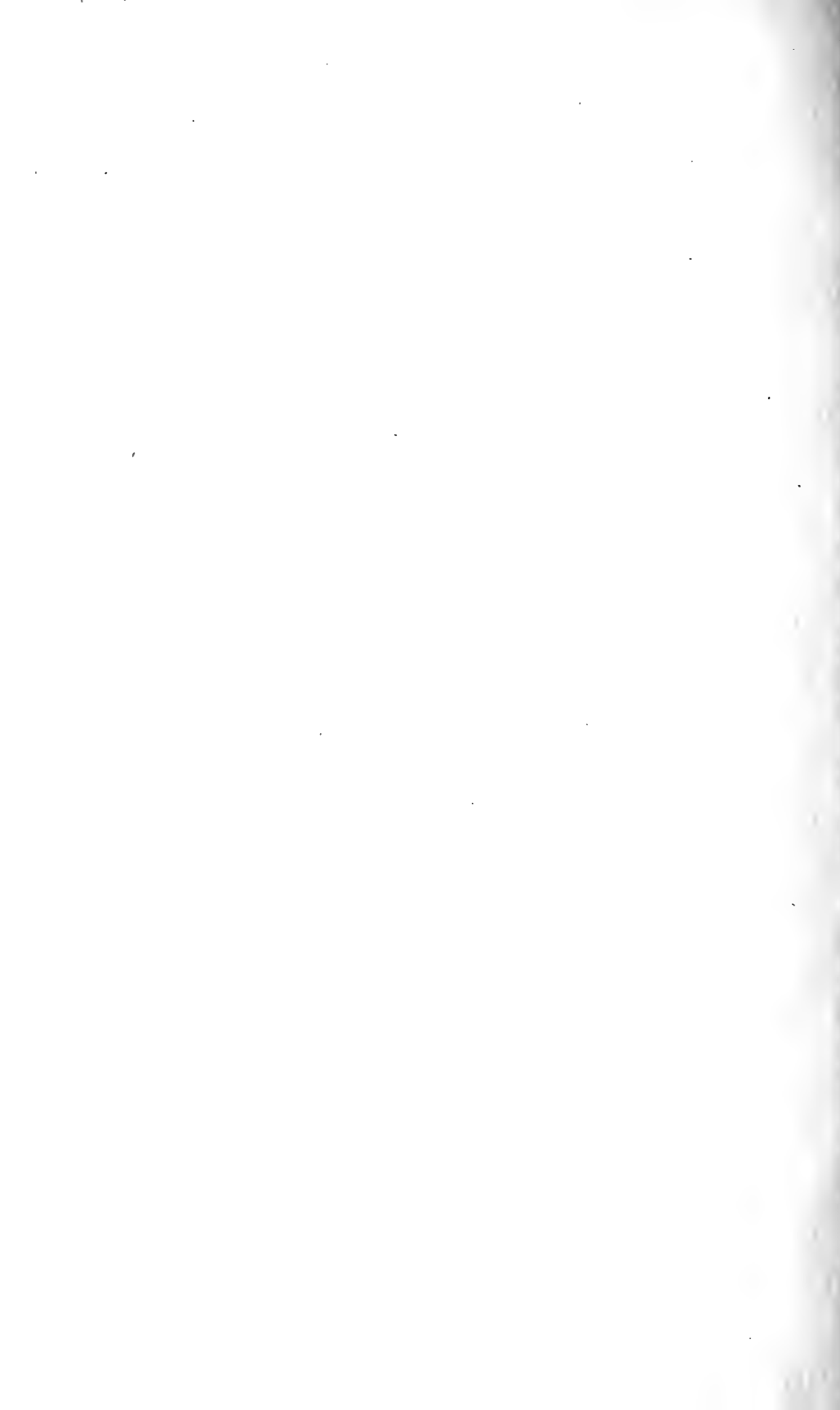
DEAN R. BRIMHALL, of Columbia University, has accepted the position of managing editor of THE SCIENTIFIC MONTHLY.

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